Mathematical Analysis

Roulette 54

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Introduction & General Procedure

1. 54 Card Roulette is played with a 54-card deck of cards, consisting of a standard 52-card deck to which two jokers have been added.

2. During the game, five cards will be dealt; the first one is referred to as the "Roulette Card" and will be used for the Roulette wagers (see below); together, all five cards will make a five-card poker hand. Jokers in the poker hand are fully wild.

3. The object of the game is for players to bet on the final result of the poker hand, as well as the specific rank and/or suit of the Roulette Card.

4. Play begins with players making one or more of the following wagers:

    a. Roulette Wagers, which will cover one or more cards and will win if the Roulette Card is one of the cards covered by the player's wager; the available Roulette Wagers are as follows:

# Covered	Examples	Payout
1	Straight-up	51:1
2	Split	25:1
3	Street	16:1
4	Corner, rank	12:1
8	Two ranks	5:1
13	Suit	3:1
16	Ace/Face	2:1
26	Black, red	1:1

b. Poker Wagers, in which the player will select a specific hand rank, and the player will win if the final five-card hand is that rank ***or higher***; the available Poker Wagers are as follows:

Wager wins on	Payout
Two pair or better	6:1
Trips or better	9:1
Straight or better	45:1
Flush or better	90:1
Full house or better	145:1
Quads or better	280:1

c. The Progressive Wager, which is made by placing $1 on a marked progressive spot at the start of the hand. The $1 wager is collected at the start of play, and as a result, the listed payouts are "for-1". The Progressive Wager pays out depending on the final five-card poker hand as follows:

Jackpot Summary

Hand	Payout
Five of a kind	(100%)
Royal flush	(20%)
Straight flush	(5%)
Quads	$100
Full house	$50
Flush	$25

i. Note that jackpot payouts (straight flush or higher) are split equally among all players that made the Progressive Wager; flat payouts (flush, full house, or quads) are paid from the float and each eligible player is paid the full flat payout separately.

5. Once all players have made their wagers, any Progressive Wagers are collected. Then, five cards will be dealt face-down onto the designated spots; one into the Roulette Card spot and the other four next to it. The house may choose to implement whatever policy of dealing, burning and card delivery it deems necessary for game protection; this will not impact the underlying mathematics.

    a. First, the Roulette Card is turned face-up, and all Roulette Wagers are resolved.

    b. Next, the remaining four poker cards are turned face up, and the five cards are read as a single five-card poker hand; based on the value of this hand, the Poker Wagers and the Progressive Wager are resolved according to the supplied paytable.

6. All cards are collected, and a new round may begin..

Methodologies

The first step of the analysis involved writing a poker evaluator that would analyze the final poker hand when passed an array of the five card numbers, represented as follows:

- 0 .. 12 = deuce .. ace of clubs
- 13 .. 25 = deuce through ace of diamonds.
- 26 .. 38 = deuce through ace of hearts.
- 39 .. 51 = deuce through ace of spades.
- 52, 53 = two jokers.

The evaluator was built on the so-called "Two Plus Two Evaluator" (Wotton, Suffecool, Senzee et al.) used under the GNU General Public Licence, with additional extensions to handle wild cards. The source code of this evaluator and a driving function is available upon request.

This evaluator was used to iterate through each possible five-card combination that could be dealt from a freshly-shuffled 54-card deck of cards, C(54, 5) = 3,162,510 in all. Each of the combinations was scored against the standard poker paytable, to determine the probability of each hand rank occurring. These probabilities were used to determine the average return to player for each wager and, from there, the overall house advantage.

The roulette wager returns were calculated with simple algebra, namely:

*Average return = P(Winning) * winning payout - P(Losing)*

Results

Poker Wagers - Summary

Wager wins on	Payout	Return	House Edge	Hit Rate:
Two pair or better	6:1	-0.065857	6.59%	13.34%
Trips or better	9:1	-0.056186	5.62%	9.44%
Straight or better	45:1	-0.047072	4.71%	2.07%
Flush or better	90:1	-0.113454	11.35%	0.97%
Full house or better	145:1	-0.103367	10.34%	0.61%
Quads or better	280:1	-0.105956	10.60%	0.32%

For the Roulette wagers, the house edge and hit rate depends on the wager selected, as follows:

Roulette Wagers - Summary

# Covered	Examples	Payout	Return	House Edge	Hit Rate:
1	Straight-up	51:1	-0.037037	3.70%	1.85%
2	Split	25:1	-0.037037	3.70%	3.70%
3	Street	16:1	-0.055556	5.56%	5.56%
4	Corner, rank	12:1	-0.037037	3.70%	7.41%
8	Two ranks	5:1	-0.111111	11.11%	14.81%
13	Suit	3:1	-0.037037	3.70%	24.07%
16	Ace/Face	2:1	-0.111111	11.11%	29.63%
26	Black, red	1:1	-0.037037	3.70%	48.15%

For the Progressive Wager, when played under optimal conditions (that is, with no other players — see below), the house edge and hit rate are as follows:

Jackpot information

Seed Value	$5,000
Jackpot Return	$0.192569
+ Flat Return	$0.533975
= Initial Return	$0.726543
+ Growth	21.00%
= Total RTP:	93.65%

Note that when played with multiple players, the return from the jackpots must be shared with all eligible players. As a result, the more players that are participating, the lower the Return to Player will be, as follows:

Effect of multiple players

# of players	Jackpot $ share	RTP%
1	$0.192569	93.65%
2	$0.096284	84.03%
3	$0.064190	80.82%
4	$0.048142	79.21%
5	$0.038514	78.25%
6	$0.032095	77.61%
7	$0.027510	77.15%
8	$0.024071	76.80%
9	$0.021397	76.54%
10	$0.019257	76.32%
11	$0.017506	76.15%
12	$0.016047	76.00%

A further breakdown of the calculations can be found in the attached spreadsheets and in the Appendix.

Results are deemed reliable

Appendix

Roulette Wagers:

Single Card Wager

Event	#(Event)	P(Event)	Payout	Value
Winners	1	0.018519	51	0.944444
Losers	53	0.981481	-1	-0.981481
Totals	54	1.000000	Return	-0.037037

Two Card Wager

Event	#(Event)	P(Event)	Payout	Value
Winners	2	0.037037	25	0.925926
Losers	52	0.962963	-1	-0.962963
Totals	54	1.000000	Return	-0.037037

Three Card Wager

Event	#(Event)	P(Event)	Payout	Value
Winners	3	0.055556	16	0.888889
Losers	51	0.944444	-1	-0.944444
Totals	54	1.000000	Return	-0.055556

Four Card Wager (corner, rank)

Event	#(Event)	P(Event)	Payout	Value
Winners	4	0.074074	12	0.888889
Losers	50	0.925926	-1	-0.925926
Totals	54	1.000000	Return	-0.037037

Eight Card Wager (two ranks)

Event	#(Event)	P(Event)	Payout	Value
Winners	8	0.148148	5	0.740741
Losers	46	0.851852	-1	-0.851852
Totals	54	1.000000	Return	-0.111111

Thirteen Card Wager (one suit)

Event	#(Event)	P(Event)	Payout	Value
Winners	13	0.240741	3	0.722222
Losers	41	0.759259	-1	-0.759259
Totals	54	1.000000	Return	-0.037037

Sixteen Card Wager (Ace or face)

Event	#(Event)	P(Event)	Payout	Value
Winners	16	0.296296	2	0.592593
Losers	38	0.703704	-1	-0.703704
Totals	54	1.000000	Return	-0.111111

Twenty-Six Card Wager (black, red)

Event	#(Event)	P(Event)	Payout	Value
Winners	26	0.481481	1	0.481481
Losers	28	0.518519	-1	-0.518519
Totals	54	1.000000	Return	-0.037037

Poker and Progressive wagers

Hand Counts for each Hand Rank

Event	#(Event)	P(Event)	Odds (1-in)
No pair	1,302,540	0.411869	2.4
One pair	1,437,936	0.454682	2.2
Two pair	123,552	0.039068	25.6
Trips	232,968	0.073666	13.6
Straight	34,704	0.010974	91.1
Flush	11,388	0.003601	277.7
Full House	9,360	0.002960	337.9
Quads	9,360	0.002960	337.9
Straight Flush	540	0.000171	5,856.5
Royal Flush	84	0.000027	37,648.9
Five of a Kind	78	0.000025	40,545.0
Totals:	3,162,510	1.000000	

Progressive Summary

Result	P(Result)	% Payout	$ Payout	$ Value
Five of a kind	0.002466%	100%	(jackpot)	$0.123320
Royal flush	0.002656%	20%	(jackpot)	$0.026561
Straight flush	0.017075%	5%	(jackpot)	$0.042688
Quads	0.295967%	(flat)	$100	$0.295967
Full house	0.295967%	(flat)	$50	$0.147984
Flush	0.360094%	(flat)	$25	$0.090023

Two Pair or better

Event	#(Event)	P(Event)	Odds (1-in)	Payout	Value
Two pair or better	422,034	0.133449	7.5	6	0.800694
All others	2,740,476	0.866551	1.2	-1	-0.866551
Totals:	3,162,510	1.000000		Return:	-0.065857

Trips or better

Event	#(Event)	P(Event)	Odds (1-in)	Payout	Value
Trips or better	298,482	0.094381	10.6	9	0.849432
All others	2,864,028	0.905619	1.1	-1	-0.905619
Totals:	3,162,510	1.000000		Return:	-0.056186

Straight or better

Event	#(Event)	P(Event)	Odds (1-in)	Payout	Value
Straight or better	65,514	0.020716	48.3	45	0.932212
All others	3,096,996	0.979284	1.0	-1	-0.979284
Totals:	3,162,510	1.000000		Return:	-0.047072

Flush or better

Event	#(Event)	P(Event)	Odds (1-in)	Payout	Value
Flush or better	30,810	0.009742	102.6	90	0.876804
All others	3,131,700	0.990258	1.0	-1	-0.990258
Totals:	3,162,510	1.000000		Return:	-0.113454

Full house or better

Event	#(Event)	P(Event)	Odds (1-in)	Payout	Value
Full house or better	19,422	0.006141	162.8	145	0.890492
All others	3,143,088	0.993859	1.0	-1	-0.993859
Totals:	**3,162,510**	**1.000000**		**Return:**	**-0.103367**

Quads or better

Event	#(Event)	P(Event)	Odds (1-in)	Payout	Value
Full house or better	10,062	0.003182	314.3	280	0.890862
All others	3,152,448	0.996818	1.0	-1	-0.996818
Totals:	**3,162,510**	**1.000000**		**Return:**	**-0.105956**