



Blackjack Cards Analysis - August 2019

The Directors

GVC Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **August 01, 2019 to August 31, 2019** as recorded by the respective game servers. The game logs were for blackjack games using 8 decks. iTech Labs has analysed the blackjack cards for statistical randomness. The results of the analysis are given below.

URLs: <https://www.bwin.be/>, <https://www.bwin.dk/>, <https://www.bwin.es/>, <https://www.bwin.fr/>, <https://www.bwin.it/>, <https://www.premiumbull.com/>, <https://www.bwin.gr/>, <https://www.bwin.com/>, <https://www.partypoker.cz/>, <https://da.partypoker.com/>, <https://danskspil.dk/>, <https://www.partypoker.fr/>, <https://www.giocodigitale.it/>, <https://www.br.betboo.com/en>, <https://www.partypremium.com>, <https://www.partypoker.es/en>, <https://www.partypoker.com/>, <https://sports.premium.com/en/sports>, <https://poker.partypoker.se/sv/poker>, <https://sports.sportingbet.com/en/sports>, <https://sports.sportingbet.gr/el/sports>, <https://www.sh.bwin.de/>, <https://sports.vistabet.com/el/sports>, <https://sports.sportingbet.co.za/en/sports>

1. Blackjack hand value

Blackjack hand value analysis involved creating subsets of data and conducting Chi-square tests on each subset. Opening hands are the value of the first two cards dealt. Final hand value is the hand value at the end of the game. Dealer final hand value is based on the fixed rules of the game. Player final hand value is dependent on player strategy choice, so has no theoretical basis for comparison.

The null hypothesis for the chi-square test is that the observed frequencies of each type of hand matches the theoretical values for a deck that has been shuffled using a perfect random number generator. The p-values observed in these multiple tests are expected to follow a uniform distribution for the range 0.0 to 1.0.

The analysis performs a KS Test (Kolmogorov-Smirnov test) for uniform distribution on the observed p-values, and the combined p-value result of this test is taken as the final result of the blackjack opening hand value statistics tests.

1.1 Player's opening score (from first two cards):

Test No.	DOF	ChiSqr	P-Value
1	17	16.42	0.49424
2	17	17.50	0.42120
3	17	13.19	0.72321
4	17	13.49	0.70302
5	17	17.92	0.39406
6	17	16.22	0.50825
7	17	16.27	0.50443
8	17	24.88	0.09746
9	17	18.19	0.37688
10	17	12.78	0.75091
11	17	17.60	0.41419
12	17	14.60	0.62415
13	17	18.42	0.36258
14	17	28.19	0.04277
15	17	13.09	0.72989
16	17	22.86	0.15391
17	17	23.43	0.13566
18	17	7.76	0.97146
19	17	16.73	0.47305

20	17	23.56	0.13197
21	17	18.50	0.35784
22	17	26.92	0.05928
23	17	16.62	0.48021
24	17	18.37	0.36605
25	17	19.73	0.28822
26	17	10.55	0.87884
27	17	19.10	0.32270
28	17	26.69	0.06272
29	17	12.03	0.79810
30	17	24.67	0.10231
31	17	27.29	0.05392
Combined P-value for all tests (Using KS method)			.14217

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

1.2 Dealer's opening score (from first two cards):

Test No.	DOF	ChiSqr	P-Value
1	17	17.55	0.41766
2	17	18.14	0.37984
3	17	15.05	0.59184
4	17	14.97	0.59796
5	17	15.76	0.54056
6	17	14.54	0.62885
7	17	13.59	0.69587
8	17	28.71	0.03731
9	17	14.89	0.60364
10	17	14.68	0.61841
11	17	10.99	0.85690
12	17	17.62	0.41299
13	17	13.41	0.70800
14	17	17.65	0.41143
15	17	15.99	0.52483
16	17	13.53	0.69997
17	17	24.21	0.11389
18	17	6.92	0.98455
19	17	13.49	0.70277
20	17	11.68	0.81921
21	17	19.62	0.29414
Combined P-value for all tests (Using KS method)			0.16254

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

1.3 Dealer's final score (total of all cards for hands with 3 or more cards):

Test No.	DOF	ChiSqr	P-Value
1	50	40.86	0.81812
2	50	52.55	0.37542
3	50	51.62	0.41018
4	50	58.47	0.19238

5	50	41.56	0.79645
6	50	60.12	0.15462
Combined P-value for all tests (Using KS method)			N/A (Insufficient data)

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

2. Blackjack rank statistics

The blackjack rank analysis aims to establish that the rank of the cards to player and dealer was equally distributed in one of the 13 possible ranks (2, 3, 4, 5, 6, 7, 8, 9, 10, J, Q, K, A).

The blackjack rank analysis involved creating subsets of data and conducting Chi-square tests on each subset. The analysis performs a KS Test (Kolmogorov-Smirnov test) for uniform distribution on the observed p-values, and the combined p-value result of this test is taken as the final result of the Ranks statistics tests.

2.1 Blackjack rank statistics for all player cards:

Test No.	DOF	ChiSqr	P-Value
1	12	23.20	0.02604
2	12	20.73	0.05441
3	12	17.15	0.14419
4	12	12.73	0.38927
5	12	12.21	0.42928
6	12	7.76	0.80359
7	12	6.56	0.88503
8	12	7.45	0.82665
9	12	14.52	0.26874
10	12	8.02	0.78357
11	12	5.50	0.93925
12	12	13.82	0.31248
13	12	9.66	0.64594
14	12	3.05	0.99515
15	12	14.47	0.27183
16	12	4.67	0.96822
17	12	16.42	0.17283
18	12	14.42	0.27494
19	12	6.54	0.88658
20	12	9.92	0.62315
21	12	16.00	0.19114
22	12	12.26	0.42519
23	12	8.70	0.72865
24	12	9.27	0.67989
25	12	6.90	0.86402
26	12	13.43	0.33871
27	12	18.47	0.10209
28	12	13.84	0.31078
29	12	21.36	0.04538
30	12	13.48	0.33514
31	12	10.41	0.57986
32	12	18.99	0.08872
33	12	8.85	0.71552
34	12	12.44	0.41102

35	12	17.59	0.12878
36	12	4.43	0.97432
37	12	20.42	0.05951
38	12	12.08	0.43960
39	12	14.65	0.26114
40	12	14.86	0.24929
41	12	3.13	0.99454
42	12	10.93	0.53476
43	12	16.03	0.18996
44	12	11.97	0.44793
45	12	25.65	0.01203
46	12	17.80	0.12203
47	12	13.84	0.31078
48	12	10.33	0.58668
49	12	14.00	0.30071
50	12	13.27	0.34958
51	12	16.70	0.16108
52	12	12.73	0.38927
53	12	3.70	0.98820
54	12	18.39	0.10424
55	12	8.23	0.76707
56	12	24.56	0.01707
57	12	17.90	0.11876
58	12	11.53	0.48412
59	12	9.84	0.63000
60	12	12.13	0.43546
61	12	8.59	0.73733
62	12	7.06	0.85332
Combined P-value for all tests (Using KS method)			0.20868

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

2.2 Blackjack rank statistics for all dealer cards:

Test No.	DOF	ChiSqr	P-Value
1	12	19.46	0.07802
2	12	18.11	0.11245
3	12	6.46	0.89114
4	12	16.65	0.16316
5	12	17.22	0.14136
6	12	6.04	0.91385
7	12	6.49	0.88963
8	12	11.89	0.45423
9	12	10.96	0.53252
10	12	12.10	0.43752
11	12	13.01	0.36817
12	12	10.07	0.60947
13	12	6.28	0.90142
14	12	8.18	0.77123
15	12	11.61	0.47765
16	12	12.78	0.38538
17	12	12.02	0.44375
18	12	10.93	0.53476

19	12	13.71	0.31934
20	12	18.89	0.09127
21	12	14.49	0.27028
22	12	11.40	0.49498
23	12	8.72	0.72647
24	12	13.25	0.35142
25	12	7.86	0.79567
26	12	17.95	0.11716
27	12	15.59	0.21094
28	12	12.67	0.39317
29	12	11.69	0.47122
30	12	12.88	0.37768
31	12	12.39	0.41504
32	12	18.78	0.09388
33	12	22.45	0.03278
34	12	9.48	0.66183
35	12	4.30	0.97735
36	12	22.29	0.03435
37	12	9.87	0.62772
38	12	13.09	0.36253
39	12	7.11	0.85026
40	12	9.53	0.65729
41	12	14.23	0.28602
42	12	8.80	0.71991
43	12	15.85	0.19839
44	12	12.52	0.40502
45	12	7.03	0.85549
46	12	11.11	0.51917
47	12	5.00	0.95785
48	12	14.36	0.27807
49	12	8.88	0.71331
50	12	12.13	0.43546
51	12	13.77	0.31590
52	12	13.06	0.36441
53	12	10.96	0.53252
54	12	12.60	0.39908
55	12	12.28	0.42315
56	12	14.96	0.24352
57	12	4.43	0.97432
58	12	9.87	0.62772
59	12	7.42	0.82851
60	12	4.13	0.98099
Combined P-value for all tests (Using KS method)			0.58229

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

4. Summary of the analysis of blackjack tests

The Blackjack cards analysis completes by combining the result of the KS Test performed in the two types of analysis (Hand Values and Ranks) for using the Holm's method and producing a single Combined P -value.

The combined p-value produced using the Holm's method is used as indication for statistical randomness.

Combination of p-values using Holm's Method		
Test	P-Value	P-Adjusted
Opening Score (Player)	0.14217	1.00000
Opening Score (Dealer)	0.16254	1.00000
Dealer's Final Score 1	0.81812	1.00000
Dealer's Final Score 2	0.37542	1.00000
Dealer's Final Score 3	0.41018	1.00000
Dealer's Final Score 4	0.19238	1.00000
Dealer's Final Score 5	0.79645	1.00000
Dealer's Final Score 6	0.15462	1.00000
Player Cards Rank	0.20868	1.00000
Dealer Cards Rank	0.58229	1.00000
Combined P-Value using Holm's Method		1.00000

Notes:

- 1) The combined p-value of all statistical tests using Holm's Method conducted for blackjack is greater than the minimum value of 0.05 which indicates that the randomness of the observed data falls within 95% confidence limits.

The final outcome of the analysis of blackjack indicates that the RNG is working correctly.

5. Conclusion

Analysis of actual data from game logs for 'player opening score', 'dealer opening score', 'dealer final score', 'player card rank' and 'dealer card rank' indicated statistical randomness. The results were satisfactory for 8 deck blackjack.

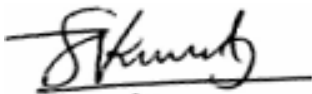
We conclude that the Random Number Generator (RNG) is working correctly.

iTech Labs has done limited sanity checks to verify the integrity of the game logs. iTech Labs also maintains a copy of the game logs for verification purposes. There were a large enough number of game records to give the calculations sufficient statistical power.

The scope of the review did not include reviews of financial controls or casino operations. We believe that the probabilities were calculated correctly from the game logs.

Please click here to see the [Original](#) report.

Signed:



Kiren Sreekumar
Principal Consultant
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Date: 25 November, 2019

Signed:



Gyulserian Hyussein
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Date: 25 November, 2019

Disclaimer.

While it is not possible to test all possible scenarios in a laboratory environment, iTech Labs has conducted a level of testing appropriate for a component test of this type.