



Blackjack Cards Analysis - April 2020

The Directors

GVC Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **April 01, 2020 to April 30, 2020** 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.party poker.cz/>, <https://da.party poker.com/>, <https://danskespil.dk/>, <https://www.party poker.fr/>, <https://www.qiocodigitale.it/>, <https://www.br.betboo.com/en/>, <https://www.party premium.com/>, <https://www.party poker.es/en/>, <https://www.party poker.com/>, <https://sports.premium.com/en/sports/>, <https://poker.party poker.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	16.74	0.47200
2	17	12.21	0.78734
3	17	9.95	0.90582
4	17	27.41	0.05227
5	17	20.88	0.23181
6	17	19.28	0.31289
7	17	12.09	0.79461
8	17	38.41	0.00216
9	17	31.74	0.01619
10	17	16.52	0.48744
11	17	11.10	0.85137
12	17	16.62	0.48016
13	17	11.05	0.85417
14	17	13.31	0.71538
15	17	22.81	0.15556
16	17	17.17	0.44313
17	17	15.57	0.55437
18	17	10.39	0.88663

19	17	19.12	0.32187
20	17	16.55	0.48520
21	17	16.74	0.47200
22	17	12.21	0.78734
23	17	9.95	0.90582
24	17	27.41	0.05227
25	17	20.88	0.23181
Combined P-value for all tests (Using KS method)			0.99264

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	10.60	0.87645
2	17	20.99	0.22666
3	17	23.69	0.12813
4	17	11.42	0.83376
5	17	14.93	0.60047
6	17	20.54	0.24762
7	17	27.62	0.04954
8	17	17.37	0.42940
9	17	22.25	0.17533
10	17	14.99	0.59653
11	17	18.22	0.37505
12	17	10.81	0.86623
13	17	22.44	0.16856
14	17	12.61	0.76199
15	17	14.22	0.65119
Combined P-value for all tests (Using KS method)			0.99978

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	47.17	0.58746
2	50	48.19	0.54630
3	50	32.68	0.97233
4	50	50.16	0.46697
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	12.78	0.38538
2	12	10.62	0.56173
3	12	17.56	0.12965
4	12	16.52	0.16848
5	12	10.65	0.55948
6	12	12.93	0.37386
7	12	8.77	0.72210
8	12	5.29	0.94758
9	12	10.78	0.54821
10	12	15.72	0.20459
11	12	8.64	0.73300
12	12	17.93	0.11796
13	12	10.10	0.60719
14	12	12.39	0.41504
15	12	16.39	0.17393
16	12	10.80	0.54596
17	12	23.59	0.02309
18	12	18.68	0.09655
19	12	16.76	0.15901
20	12	23.91	0.02095
21	12	12.00	0.44584
22	12	8.80	0.71991
23	12	11.45	0.49063
24	12	12.83	0.38152
25	12	12.00	0.44584
26	12	8.96	0.70668
27	12	5.68	0.93135
28	12	20.16	0.06408
29	12	9.89	0.62543
30	12	5.89	0.92162
31	12	11.58	0.47981
32	12	7.45	0.82665
33	12	9.63	0.64821
34	12	19.77	0.07152
35	12	11.84	0.45845
36	12	17.67	0.12621
37	12	9.37	0.67087
38	12	11.53	0.48412
39	12	7.76	0.80359
40	12	6.98	0.85903
Combined P-value for all tests (Using KS method)			0.87147

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	7.58	0.81718
2	12	5.11	0.95427
3	12	23.18	0.02625
4	12	8.23	0.76707
5	12	9.79	0.63455
6	12	9.53	0.65729
7	12	10.59	0.56400
8	12	14.62	0.26265
9	12	12.10	0.43752
10	12	6.72	0.87555
11	12	7.53	0.82099
12	12	21.36	0.04538
13	12	10.62	0.56173
14	12	8.62	0.73517
15	12	15.22	0.22952
16	12	14.94	0.24496
17	12	11.89	0.45423
18	12	12.23	0.42723
19	12	13.19	0.35510
20	12	13.48	0.33514
21	12	6.88	0.86570
22	12	22.09	0.03657
23	12	11.97	0.44793
24	12	8.90	0.71111
25	12	10.65	0.55948
26	12	10.05	0.61175
27	12	10.15	0.60263
28	12	5.26	0.94857
29	12	6.54	0.88658
30	12	4.15	0.98066
31	12	11.50	0.48629
32	12	14.52	0.26874
33	12	4.09	0.98168
34	12	8.07	0.77948
35	12	6.49	0.88963
36	12	12.44	0.41102
37	12	11.17	0.51475
38	12	10.02	0.61403
39	12	7.60	0.81526
40	12	7.08	0.85201
41	12	12.31	0.42112
42	12	6.38	0.89562
43	12	8.98	0.70447
44	12	7.20	0.84420
Combined P-value for all tests (Using KS method)			0.04017

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)	0.99264	1.00000
Opening Score (Dealer)	0.99978	1.00000
Dealer's Final Score 1	0.58746	1.00000
Dealer's Final Score 2	0.54630	1.00000
Dealer's Final Score 3	0.97233	1.00000
Dealer's Final Score 4	0.46697	1.00000
Player Cards Rank	0.87147	1.00000
Dealer Cards Rank	0.04017	0.32139
Combined P-Value using Holm's Method		0.32139

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.

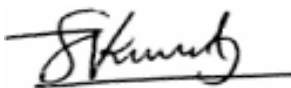
We conclude that the Random Number Generator (RNG) is working correctly.

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:



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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.