



Blackjack Cards Analysis - December 2019

The Directors

GVC Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **December 01, 2019 to December 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	14.94	0.59953
2	17	22.01	0.18448
3	17	11.43	0.83323
4	17	12.02	0.79895
5	17	24.60	0.10397
6	17	18.24	0.37408
7	17	30.41	0.02351
8	17	12.00	0.79995
9	17	9.62	0.91886
10	17	20.37	0.25561
11	17	18.77	0.34193
12	17	25.53	0.08344
13	17	18.97	0.33001
14	17	14.08	0.66167
15	17	11.62	0.82273
16	17	21.27	0.21427
17	17	23.88	0.12262
18	17	23.24	0.14167
19	17	11.59	0.82414

20	17	15.79	0.53886
21	17	20.90	0.23064
Combined P-value for all tests (Using KS method)			0.69839

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	19.18	0.31815
2	17	11.61	0.82310
3	17	14.18	0.65426
4	17	31.35	0.01811
5	17	16.40	0.49588
6	17	23.83	0.12412
7	17	18.46	0.36063
8	17	15.03	0.59366
9	17	29.85	0.02743
10	17	27.10	0.05661
11	17	15.77	0.54050
12	17	13.70	0.68841
13	17	17.52	0.41977
Combined P-value for all tests (Using KS method)			0.87406

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	38.08	0.89157
2	50	52.41	0.38070
3	50	47.70	0.56635
4	50	37.99	0.89356
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
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1	12	16.50	0.16956
2	12	12.52	0.40502
3	12	5.16	0.95242
4	12	13.43	0.33871
5	12	13.92	0.30572
6	12	4.72	0.96674
7	12	12.08	0.43960
8	12	8.44	0.75020
9	12	19.38	0.07972
10	12	17.25	0.14043
11	12	12.99	0.37006
12	12	16.89	0.15394
13	12	14.34	0.27965
14	12	24.09	0.01979
15	12	7.79	0.80162
16	12	13.77	0.31590
17	12	9.24	0.68213
18	12	10.62	0.56173
19	12	7.16	0.84672
20	12	17.93	0.11796
21	12	15.38	0.22141
22	12	11.45	0.49063
23	12	12.99	0.37006
24	12	6.46	0.89114
25	12	10.10	0.60719
26	12	11.43	0.49281
27	12	11.97	0.44793
28	12	14.99	0.24209
29	12	15.30	0.22544
30	12	6.12	0.90981
31	12	8.10	0.77743
32	12	12.54	0.40304
33	12	15.20	0.23089
34	12	6.38	0.89562
35	12	13.04	0.36628
36	12	8.54	0.74164
37	12	16.29	0.17840
38	12	13.45	0.33692
39	12	18.63	0.09791
40	12	8.20	0.76915
41	12	4.69	0.96748
42	12	11.14	0.51696
43	12	20.47	0.05874
Combined P-value for all tests (Using KS method)			0.62933

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	7.55	0.81909
2	12	12.70	0.39122
3	12	12.28	0.42315
4	12	17.12	0.14514

5	12	17.69	0.12537
6	12	3.05	0.99515
7	12	11.56	0.48196
8	12	11.76	0.46481
9	12	9.01	0.70225
10	12	13.19	0.35510
11	12	16.31	0.17727
12	12	14.57	0.26568
13	12	7.53	0.82099
14	12	2.07	0.99930
15	12	7.11	0.85026
16	12	11.01	0.52806
17	12	18.73	0.09520
18	12	17.25	0.14043
19	12	12.13	0.43546
20	12	12.52	0.40502
21	12	9.14	0.69110
22	12	13.09	0.36253
23	12	11.01	0.52806
24	12	22.16	0.03572
25	12	7.89	0.79367
26	12	6.93	0.86233
27	12	13.19	0.35510
28	12	13.74	0.31762
29	12	16.44	0.17174
30	12	8.93	0.70890
31	12	12.62	0.39710
32	12	7.27	0.83955
33	12	11.24	0.50813
34	12	21.85	0.03921
35	12	7.01	0.85722
36	12	7.99	0.78560
37	12	22.55	0.03176
38	12	2.98	0.99571
39	12	5.22	0.95029
Combined P-value for all tests (Using KS method)			0.87026

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)	0.69839	1.00000
Opening Score (Dealer)	0.87406	1.00000
Dealer's Final Score 1	0.89157	1.00000
Dealer's Final Score 2	0.38070	1.00000
Dealer's Final Score 3	0.56635	1.00000

Dealer's Final Score 4	0.89356	1.00000
Player Cards Rank	0.62933	1.00000
Dealer Cards Rank	0.87026	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.

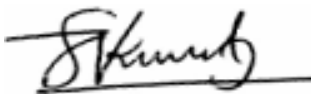
We conclude that the Random Number Generator (RNG) is working correctly.

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:



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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.