



## Blackjack Cards Analysis - March 2020

### The Directors

GVC Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **March 01, 2020 to March 31, 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://danskspil.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	14.50	0.63138
2	17	20.65	0.24250
3	17	17.66	0.41040
4	17	11.17	0.84755
5	17	16.65	0.47802
6	17	13.23	0.72073
7	17	20.50	0.24952
8	17	23.41	0.13652
9	17	26.77	0.06159
10	17	18.51	0.35764
11	17	9.52	0.92253
12	17	11.37	0.83644
13	17	19.24	0.31471
14	17	12.19	0.78854
15	17	21.37	0.21011
16	17	16.95	0.45747
17	17	21.49	0.20516
18	17	22.31	0.17298

19	17	25.31	0.08792
20	17	15.25	0.57747
21	17	12.07	0.79617
22	17	21.61	0.20039
23	17	11.05	0.85376
24	17	9.86	0.90941
25	17	11.21	0.84535
Combined P-value for all tests (Using KS method)			0.91445

*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	17.72	0.40648
2	17	17.68	0.40900
3	17	16.05	0.52004
4	17	23.49	0.13404
5	17	18.32	0.36911
6	17	10.87	0.86346
7	17	31.72	0.01631
8	17	16.53	0.48696
9	17	14.40	0.63860
10	17	15.67	0.54744
11	17	15.44	0.56365
12	17	27.29	0.05400
13	17	19.53	0.29880
14	17	13.62	0.69412
15	17	11.32	0.83955
Combined P-value for all tests (Using KS method)			0.99347

*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	46.07	0.63165
2	50	44.15	0.70601
3	50	48.32	0.54120
4	50	62.04	0.11816
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	7.66	0.81140
2	12	6.12	0.90981
3	12	9.27	0.67989
4	12	11.82	0.46057
5	12	13.25	0.35142
6	12	8.41	0.75233
7	12	7.66	0.81140
8	12	25.36	0.01320
9	12	11.84	0.45845
10	12	7.16	0.84672
11	12	15.25	0.22815
12	12	14.42	0.27494
13	12	15.40	0.22008
14	12	14.65	0.26114
15	12	9.94	0.62087
16	12	18.03	0.11478
17	12	14.68	0.25964
18	12	5.81	0.92536
19	12	12.36	0.41706
20	12	12.18	0.43133
21	12	13.92	0.30572
22	12	12.99	0.37006
23	12	16.76	0.15901
24	12	14.36	0.27807
25	12	16.65	0.16316
26	12	14.65	0.26114
27	12	4.59	0.97035
28	12	14.42	0.27494
29	12	15.07	0.23785
30	12	8.90	0.71111
31	12	13.82	0.31248
32	12	6.90	0.86402
33	12	10.44	0.57759
34	12	7.14	0.84850
35	12	21.36	0.04538
36	12	13.32	0.34594
37	12	8.83	0.71772
38	12	8.90	0.71111
39	12	27.57	0.00639
40	12	10.00	0.61631
41	12	8.98	0.70447
42	12	13.19	0.35510
43	12	8.31	0.76078
44	12	15.25	0.22815
45	12	9.29	0.67763
46	12	11.37	0.49717
47	12	9.66	0.64594

48	12	10.78	0.54821
49	12	7.99	0.78560
50	12	6.55	0.88567
Combined P-value for all tests (Using KS method)			0.67562

*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	14.00	0.30071
2	12	21.64	0.04171
3	12	19.41	0.07915
4	12	14.75	0.25517
5	12	12.62	0.39710
6	12	23.98	0.02044
7	12	8.10	0.77743
8	12	12.78	0.38538
9	12	8.80	0.71991
10	12	15.48	0.21613
11	12	14.94	0.24496
12	12	16.52	0.16848
13	12	9.32	0.67538
14	12	5.65	0.93251
15	12	10.54	0.56852
16	12	8.59	0.73733
17	12	9.01	0.70225
18	12	8.96	0.70668
19	12	7.24	0.84135
20	12	18.45	0.10280
21	12	7.45	0.82665
22	12	8.96	0.70668
23	12	10.33	0.58668
24	12	10.62	0.56173
25	12	8.67	0.73083
26	12	21.07	0.04934
27	12	11.76	0.46481
28	12	12.18	0.43133
29	12	19.30	0.08145
30	12	20.24	0.06268
31	12	9.87	0.62772
32	12	11.30	0.50374
33	12	21.20	0.04750
34	12	7.27	0.83955
35	12	7.24	0.84135
36	12	6.56	0.88503
37	12	4.30	0.97735
38	12	13.40	0.34051
39	12	11.45	0.49063
40	12	6.69	0.87716
41	12	18.29	0.10716
42	12	17.87	0.11975

Combined P-value for all tests (Using KS method)			0.82867

*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.

<b>Combination of p-values using Holm's Method</b>		
<b>Test</b>	<b>P-Value</b>	<b>P-Adjusted</b>
Opening Score (Player)	0.91445	1.00000
Opening Score (Dealer)	0.99347	1.00000
Dealer's Final Score 1	0.63165	1.00000
Dealer's Final Score 2	0.70601	1.00000
Dealer's Final Score 3	0.54120	1.00000
Dealer's Final Score 4	0.11816	0.94532
Player Cards Rank	0.67562	1.00000
Dealer Cards Rank	0.82867	1.00000
<b>Combined P-Value using Holm's Method</b>		0.94532

*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.

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**Signed:**



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Date: 30 April, 2020

**Signed:**



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Date: 30 April, 2020

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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.