Blackjack Cards Analysis - January 2020

The Directors
GVC Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **January 01, 2020** to **January 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.partypoker.cz/, https://da.partypoker.com/, https://danskespil.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	20.49	0.25013
2	17	12.17	0.78943
3	17	13.27	0.71818
4	17	6.20	0.99172
5	17	13.74	0.68518
6	17	6.32	0.99077
7	17	20.94	0.22892
8	17	15.28	0.57506
9	17	29.64	0.02909
10	17	16.79	0.46837
Combined P-value for all tests (Using KS method)			0.81813

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	14.73	0.61505
2	17	18.38	0.36554
3	17	16.58	0.48284
4	17	13.17	0.72465
5	17	12.95	0.73985
6	17	6.97	0.98393
7	17	22.60	0.16287
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.

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	64.49	0.08172
2	50	38.38	0.88455
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	15.01	0.24067
2	12	11.79	0.46269
3	12	10.85	0.54147
4	12	11.53	0.48412
5	12	11.63	0.47550
6	12	14.21	0.28762
7	12	2.79	0.99683
8	12	13.22	0.35326
9	12	21.85	0.03921
10	12	24.06	0.01995
11	12	11.32	0.50154
12	12	8.80	0.71991
13	12	16.03	0.18996
14	12	5.13	0.95335
15	12	14.88	0.24784

16	12	14.73	0.25665
17	12	6.93	0.86233
18	12	9.50	0.65956
19	12	11.35	0.49935
20	12	7.84	0.79766
21	12	16.35	0.17558
Combined P-value for all tests (Using KS method)			0.87502

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	16.42	0.17283
2	12	14.03	0.29905
3	12	12.91	0.37576
4	12	8.77	0.72210
5	12	9.27	0.67989
6	12	7.55	0.81909
7	12	9.24	0.68213
8	12	7.45	0.82665
9	12	9.66	0.64594
10	12	15.43	0.21876
11	12	10.23	0.59579
12	12	15.61	0.20966
13	12	7.86	0.79567
14	12	15.30	0.22544
15	12	8.41	0.75233
16	12	17.74	0.12369
17	12	6.38	0.89562
18	12	10.23	0.59579
19	12	15.25	0.22815
20	12	16.78	0.15798
21	12	12.65	0.39461
Combined P-value for all tests (Using KS method)			0.88397

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)	0.81813	1.00000

Opening Score (Dealer) 1	0.61505	1.00000
Opening Score (Dealer) 2	0.36554	1.00000
Opening Score (Dealer) 3	0.48284	1.00000
Opening Score (Dealer) 4	0.72465	1.00000
Opening Score (Dealer) 5	0.73985	1.00000
Opening Score (Dealer) 6	0.98393	1.00000
Opening Score (Dealer) 7	0.16287	1.00000
Dealer's Final Score 1	0.08172	0.98061
Dealer's Final Score 2	0.88455	1.00000
Player Cards Rank	0.87502	1.00000
Dealer Cards Rank	0.88397	1.00000
Combined P-Value using Holm's Method		0.98061

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
iTech Labs Australia
Date: 16 March, 2020

Signed:

Gyulserian Hyussein
Senior Consultant
iTech Labs Australia
Date: 16 March, 2020

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.