



Blackjack Cards Analysis – January 2024

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **January 01, 2024 to January 31, 2024** 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.

For details on the gaming sites serviced by the Entain Plc game servers and used in this audit refer to the [List](#).

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	10.02	0.90298
2	17	8.18	0.96246
3	17	16.77	0.46989
4	17	7.11	0.98203
5	17	19.01	0.32784
6	17	20.03	0.27287
7	17	29.63	0.02913
8	17	24.04	0.11822
9	17	24.23	0.11330
10	17	13.76	0.68423
11	17	19.29	0.31226
12	17	19.89	0.28005
13	17	20.00	0.27401
14	17	12.32	0.78039
15	17	8.97	0.94133
16	17	8.09	0.96461
17	17	14.19	0.65371
18	17	17.35	0.43089
19	17	17.51	0.42005
20	17	15.94	0.52798
21	17	17.29	0.43498

22	17	27.26	0.05432
23	17	19.22	0.31606
24	17	19.05	0.32585
25	17	20.64	0.24293
26	17	27.40	0.05240
27	17	9.16	0.93509
28	17	17.44	0.42496
29	17	17.61	0.41395
30	17	15.03	0.59297
31	17	18.99	0.32939
32	17	11.16	0.84831
33	17	18.33	0.36807
34	17	14.30	0.64594
35	17	22.57	0.16371
36	17	6.79	0.98611
37	17	15.75	0.54178
38	17	5.25	0.99696
39	17	5.53	0.99581
40	17	23.89	0.12257
41	17	13.81	0.68033
42	17	19.04	0.32612
43	17	22.39	0.17012
44	17	17.74	0.40572
45	17	22.58	0.16328
46	17	26.86	0.06011
47	17	18.28	0.37157
48	17	14.89	0.60313
49	17	20.72	0.23918
50	17	27.52	0.05081
51	17	17.56	0.41723
52	17	26.48	0.06621
53	17	12.01	0.79950
54	17	20.42	0.25338
55	17	9.72	0.91506
56	17	9.51	0.92287
57	17	11.92	0.80508
58	17	14.20	0.65295
59	17	8.53	0.95377
60	17	6.37	0.99035
61	17	9.43	0.92594
62	17	8.88	0.94402
63	17	8.55	0.95331
64	17	19.69	0.29064
65	17	18.78	0.34145
66	17	15.98	0.52557
67	17	23.21	0.14260
68	17	9.61	0.91909
69	17	19.74	0.28790
70	17	16.44	0.49300

71	17	23.02	0.14873
72	17	25.90	0.07627
73	17	12.74	0.75373
74	17	20.47	0.25077
75	17	18.79	0.34080
76	17	35.96	0.00464
77	17	14.28	0.64684
78	17	15.03	0.59315
79	17	23.64	0.12945
80	17	12.47	0.77065
81	17	40.86	0.00098
82	17	14.43	0.63632
83	17	11.11	0.85094
84	17	15.39	0.56773
85	17	8.37	0.95797
86	17	22.46	0.16763
87	17	19.19	0.31776
88	17	20.80	0.23541
89	17	8.65	0.95051
90	17	29.92	0.02694
91	17	8.87	0.94417
92	17	20.24	0.26198
93	17	17.10	0.44773
94	17	13.68	0.68950
95	17	13.27	0.71778
96	17	8.61	0.95162
97	17	16.62	0.48012
98	17	16.83	0.46592
99	17	17.60	0.41427
100	17	13.65	0.69198
Combined P-value for all tests (Using KS method)			0.13202

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	19.86	0.28135
2	17	13.89	0.67461
3	17	13.79	0.68209
4	17	14.21	0.65203
5	17	10.45	0.88371
6	17	29.05	0.03410
7	17	19.77	0.28625
8	17	13.64	0.69247
9	17	16.13	0.51464
10	17	21.84	0.19083
11	17	13.24	0.71964
12	17	18.27	0.37220

13	17	16.03	0.52148
14	17	15.42	0.56542
15	17	11.21	0.84531
16	17	12.07	0.79601
17	17	22.97	0.15031
18	17	15.63	0.55015
19	17	13.63	0.69340
20	17	25.45	0.08516
21	17	12.26	0.78431
22	17	15.17	0.58341
23	17	11.95	0.80335
24	17	18.96	0.33090
25	17	11.24	0.84404
26	17	29.30	0.03184
27	17	11.62	0.82244
28	17	26.23	0.07041
29	17	26.27	0.06968
30	17	14.87	0.60499
31	17	21.22	0.21645
32	17	7.43	0.97734
33	17	10.57	0.87802
34	17	22.38	0.17050
35	17	14.33	0.64386
36	17	15.99	0.52480
37	17	17.90	0.39495
38	17	12.79	0.75000
39	17	32.88	0.01168
40	17	23.67	0.12856
41	17	19.85	0.28190
42	17	16.61	0.48094
43	17	29.91	0.02699
44	17	7.32	0.97903
45	17	29.59	0.02948
46	17	27.65	0.04916
47	17	12.32	0.78049
48	17	13.30	0.71562
49	17	13.70	0.68804
50	17	13.03	0.73439
51	17	11.84	0.80992
52	17	23.51	0.13344
53	17	17.76	0.40404
54	17	17.13	0.44570
55	17	12.62	0.76108
56	17	16.80	0.46826
57	17	14.96	0.59849
58	17	15.10	0.58833
59	17	19.63	0.29365
60	17	12.46	0.77150
61	17	23.39	0.13708

62	17	18.38	0.36528
63	17	15.81	0.53734
64	17	9.16	0.93507
65	17	21.48	0.20549
66	17	30.74	0.02147
67	17	20.66	0.24177
68	17	19.17	0.31909
69	17	8.57	0.95291
70	17	19.49	0.30112
71	17	18.91	0.33344
72	17	16.32	0.50109
73	17	15.53	0.55714
74	17	9.43	0.92572
75	17	8.74	0.94819
76	17	14.66	0.61984
77	17	14.01	0.66614
78	17	9.62	0.91864
79	17	20.06	0.27101
80	17	17.91	0.39464
81	17	16.83	0.46620
82	17	16.05	0.52043
83	17	18.79	0.34068
84	17	7.13	0.98186
85	17	10.55	0.87896
86	17	20.99	0.22669
87	17	11.04	0.85433
88	17	14.18	0.65425
89	17	15.38	0.56802
90	17	15.39	0.56740
91	17	12.13	0.79218
92	17	17.45	0.42440
93	17	11.51	0.82905
94	17	11.88	0.80717
95	17	10.11	0.89888
96	17	22.47	0.16722
97	17	16.33	0.50041
98	17	22.18	0.17806
99	17	19.64	0.29311
100	17	30.93	0.02036
Combined P-value for all tests (Using KS method)			0.84797

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	48.53	0.53263
2	50	52.82	0.36554
3	50	59.28	0.17308

4	50	47.55	0.57223
5	50	49.66	0.48689
6	50	33.64	0.96324
7	50	49.77	0.48276
8	50	37.27	0.90869
9	50	58.83	0.18365
10	50	51.45	0.41686
11	50	65.70	0.06733
12	50	55.23	0.28365
13	50	54.25	0.31552
14	50	66.46	0.05952
15	50	38.01	0.89311
16	50	51.77	0.40446
17	50	48.26	0.54326
18	50	40.91	0.81665
19	50	56.00	0.25976
20	50	46.18	0.62727
21	50	56.21	0.25350
22	50	53.07	0.35656
23	50	65.07	0.07454
24	50	43.72	0.72192
25	50	71.52	0.02453
26	50	45.85	0.64055
27	50	50.35	0.45948
28	50	48.77	0.52270
29	50	51.15	0.42826
30	50	34.30	0.95584
31	50	48.48	0.53455
32	50	69.44	0.03579
33	50	46.87	0.59972
34	50	39.59	0.85434
35	50	49.91	0.47703
36	50	43.23	0.73972
37	50	44.36	0.69828
38	50	51.29	0.42296
39	50	57.48	0.21792
40	50	56.96	0.23217
41	50	46.68	0.60739
42	50	61.76	0.12290
43	50	60.47	0.14755
44	50	33.57	0.96400
45	50	57.53	0.21659
46	50	45.84	0.64089
47	50	39.03	0.86899
48	50	34.28	0.95605
49	50	51.09	0.43057
50	50	64.59	0.08037
51	50	43.15	0.74272
52	50	29.75	0.98983

53	50	29.48	0.99084
54	50	52.64	0.37227
55	50	50.81	0.44159
56	50	48.98	0.51445
57	50	39.30	0.86208
58	50	38.03	0.89270
59	50	62.67	0.10762
60	50	31.69	0.97983
61	50	41.52	0.79787
62	50	42.39	0.76923
63	50	45.38	0.65909
64	50	38.85	0.87351
65	50	54.11	0.32043
66	50	56.93	0.23277
67	50	45.46	0.65578
68	50	43.12	0.74382
69	50	66.29	0.06122
70	50	37.10	0.91206
71	50	48.90	0.51740
72	50	41.34	0.80344
73	50	50.15	0.46730
74	50	36.84	0.91696
75	50	37.57	0.90248
76	50	60.38	0.14938
77	50	68.76	0.04028
78	50	60.69	0.14311
79	50	44.66	0.68677
80	50	67.87	0.04698
81	50	54.85	0.29583
82	50	53.63	0.33707
83	50	59.60	0.16604
84	50	51.32	0.42173
85	50	65.16	0.07347
86	50	70.31	0.03060
87	50	54.51	0.30715
88	50	53.77	0.33198
89	50	49.82	0.48068
90	50	50.35	0.45956
91	50	60.23	0.15236
92	50	56.57	0.24310
93	50	31.54	0.98080
94	50	48.15	0.54795
95	50	67.26	0.05207
96	50	41.18	0.80829
97	50	48.68	0.52624
98	50	38.79	0.87497
99	50	48.76	0.52329
100	50	50.73	0.44461
Combined P-value for all tests			0.82428

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	12.82	0.38218
2	12	6.25	0.90277
3	12	11.35	0.49948
4	12	7.93	0.79062
5	12	10.75	0.55067
6	12	17.47	0.13279
7	12	11.47	0.48879
8	12	14.65	0.26099
9	12	11.53	0.48387
10	12	8.22	0.76799
11	12	6.60	0.88291
12	12	5.56	0.93653
13	12	9.54	0.65651
14	12	17.07	0.14717
15	12	7.25	0.84056
16	12	11.05	0.52490
17	12	13.39	0.34155
18	12	8.01	0.78431
19	12	16.33	0.17676
20	12	16.70	0.16129
21	12	20.03	0.06644
22	12	15.34	0.22357
23	12	10.61	0.56265
24	12	16.83	0.15609
25	12	11.29	0.50466
26	12	10.08	0.60925
27	12	14.22	0.28707
28	12	13.97	0.30234
29	12	12.53	0.40414
30	12	19.87	0.06950
31	12	6.74	0.87462
32	12	14.21	0.28734
33	12	15.90	0.19593
34	12	9.31	0.67608
35	12	8.47	0.74753
36	12	20.73	0.05448
37	12	6.18	0.90695

38	12	9.56	0.65481
39	12	6.56	0.88512
40	12	10.99	0.52973
41	12	11.23	0.50894
42	12	12.16	0.43292
43	12	14.17	0.28983
44	12	6.96	0.86018
45	12	7.79	0.80124
46	12	5.53	0.93773
47	12	15.77	0.20193
48	12	17.32	0.13797
49	12	21.14	0.04835
50	12	12.05	0.44179
51	12	11.99	0.44632
52	12	8.02	0.78341
53	12	6.66	0.87945
54	12	15.80	0.20038
55	12	8.55	0.74069
56	12	16.71	0.16070
57	12	13.19	0.35556
58	12	10.46	0.57563
59	12	6.77	0.87215
60	12	9.14	0.69132
61	12	11.41	0.49419
62	12	8.24	0.76581
63	12	21.88	0.03892
64	12	15.97	0.19272
65	12	16.70	0.16106
66	12	9.39	0.66912
67	12	8.09	0.77832
68	12	17.67	0.12621
69	12	8.30	0.76110
70	12	10.11	0.60646
71	12	9.95	0.62070
72	12	5.36	0.94478
73	12	7.27	0.83900
74	12	6.98	0.85887
75	12	16.18	0.18295
76	12	20.84	0.05277
77	12	10.00	0.61623
78	12	19.58	0.07550
79	12	7.71	0.80733
80	12	9.08	0.69607
81	12	10.45	0.57622
82	12	16.26	0.17981
83	12	15.81	0.20018
84	12	8.52	0.74330
85	12	7.70	0.80818
86	12	10.33	0.58673

87	12	11.35	0.49894
88	12	10.58	0.56506
89	12	11.40	0.49457
90	12	8.33	0.75892
91	12	12.29	0.42238
92	12	8.01	0.78456
93	12	13.73	0.31817
94	12	6.27	0.90186
95	12	11.17	0.51442
96	12	11.28	0.50523
97	12	18.03	0.11489
98	12	16.02	0.19031
99	12	19.20	0.08370
100	12	16.27	0.17935
Combined P-value for all tests (Using KS method)			0.79647

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	9.86	0.62795
2	12	15.43	0.21858
3	12	12.76	0.38648
4	12	10.14	0.60341
5	12	8.49	0.74581
6	12	12.74	0.38815
7	12	8.22	0.76775
8	12	14.98	0.24241
9	12	1.51	0.99986
10	12	13.18	0.35596
11	12	21.76	0.04030
12	12	9.89	0.62521
13	12	11.87	0.45593
14	12	8.10	0.77719
15	12	15.58	0.21104
16	12	16.70	0.16116
17	12	10.91	0.53673
18	12	22.58	0.03155
19	12	10.74	0.55143
20	12	8.63	0.73449
21	12	12.06	0.44049
22	12	12.39	0.41485
23	12	8.89	0.71219
24	12	6.42	0.89338
25	12	20.14	0.06440
26	12	7.95	0.78878
27	12	7.42	0.82859
28	12	12.01	0.44466
29	12	20.39	0.06012
30	12	11.02	0.52702
31	12	12.49	0.40690
32	12	14.24	0.28552

33	12	11.17	0.51428
34	12	5.97	0.91764
35	12	9.29	0.67773
36	12	18.06	0.11397
37	12	16.26	0.17962
38	12	11.20	0.51211
39	12	5.01	0.95773
40	12	12.42	0.41291
41	12	21.91	0.03849
42	12	6.97	0.85934
43	12	5.89	0.92170
44	12	12.19	0.43041
45	12	8.56	0.73978
46	12	6.67	0.87885
47	12	13.61	0.32617
48	12	15.14	0.23379
49	12	18.28	0.10747
50	12	11.63	0.47559
51	12	17.72	0.12446
52	12	10.47	0.57484
53	12	12.07	0.43984
54	12	9.43	0.66547
55	12	24.65	0.01659
56	12	6.75	0.87393
57	12	7.69	0.80920
58	12	15.32	0.22420
59	12	6.12	0.90984
60	12	19.24	0.08281
61	12	13.45	0.33731
62	12	14.36	0.27801
63	12	15.62	0.20936
64	12	8.34	0.75823
65	12	12.02	0.44417
66	12	20.82	0.05306
67	12	21.05	0.04963
68	12	14.59	0.26449
69	12	6.86	0.86701
70	12	17.10	0.14593
71	12	8.32	0.75926
72	12	12.91	0.37592
73	12	5.87	0.92231
74	12	15.12	0.23491
75	12	11.36	0.49867
76	12	11.28	0.50486
77	12	3.79	0.98692
78	12	9.64	0.64759
79	12	5.91	0.92031
80	12	17.70	0.12524
81	12	13.20	0.35470
82	12	8.58	0.73792
83	12	9.80	0.63344
84	12	18.59	0.09898
85	12	7.96	0.78822
86	12	9.66	0.64598
87	12	7.34	0.83432
88	12	14.01	0.30009

89	12	16.20	0.18232
90	12	6.88	0.86567
91	12	10.58	0.56497
92	12	6.02	0.91528
93	12	11.26	0.50645
94	12	11.75	0.46615
95	12	6.57	0.88458
96	12	3.59	0.98976
97	12	13.09	0.36221
98	12	13.86	0.30979
99	12	6.22	0.90443
100	12	8.63	0.73387
Combined P-value for all tests (Using KS method)			0.92702

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)	0.13202	0.66009
Opening Score (Dealer)	0.84797	1.00000
Dealer's Final Score	0.82428	1.00000
Player Cards Rank	0.79647	1.00000
Dealer Cards Rank	0.92702	1.00000
Combined P-Value using Holm's Method		0.66009

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:



Divya Bhargava
Project Manager
iTech Labs Australia
Date: 29 February 2024

Signed:



Alvin Rizaldi
Chief Executive Officer
iTech Labs Australia
Date: 29 February 2024

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.