



Blackjack Cards Analysis – July 2024

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **July 01, 2024, to July 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	13.46	0.70507
2	17	20.91	0.23033
3	17	16.51	0.48788
4	17	16.28	0.50440
5	17	14.21	0.65240
6	17	16.04	0.52114
7	17	27.32	0.05357
8	17	23.11	0.14565
9	17	23.90	0.12231
10	17	15.77	0.54032
11	17	21.76	0.19407
12	17	11.81	0.81170
13	17	11.51	0.82906
14	17	15.79	0.53855
15	17	13.92	0.67275
16	17	17.77	0.40362
17	17	21.28	0.21388
18	17	18.62	0.35049
19	17	17.19	0.44148
20	17	18.13	0.38097
21	17	17.56	0.41690

22	17	15.63	0.55022
23	17	15.65	0.54901
24	17	20.41	0.25363
25	17	11.34	0.83834
26	17	22.34	0.17183
27	17	10.69	0.87215
28	17	12.43	0.77350
29	17	15.51	0.55892
30	17	12.16	0.79026
31	17	15.17	0.58343
32	17	12.25	0.78494
33	17	18.26	0.37282
34	17	15.50	0.55953
35	17	15.68	0.54689
36	17	10.95	0.85904
37	17	24.35	0.11022
38	17	14.46	0.63410
39	17	9.63	0.91849
40	17	19.23	0.31551
41	17	19.59	0.29563
42	17	8.59	0.95225
43	17	9.75	0.91377
44	17	13.88	0.67531
45	17	12.37	0.77747
46	17	18.07	0.38459
47	17	14.71	0.61669
48	17	15.35	0.57005
49	17	15.11	0.58723
50	17	14.57	0.62663
51	17	12.73	0.75425
52	17	10.89	0.86244
53	17	21.58	0.20156
54	17	8.94	0.94207
55	17	23.43	0.13571
56	17	18.35	0.36708
57	17	11.40	0.83513
58	17	13.26	0.71854
59	17	24.16	0.11509
60	17	8.47	0.95549
61	17	18.49	0.35861
62	17	14.21	0.65252
63	17	18.15	0.37929
64	17	13.96	0.66974
65	17	8.14	0.96353
66	17	10.09	0.89991
67	17	27.35	0.05308
68	17	10.77	0.86849
69	17	15.46	0.56229
70	17	24.23	0.11326

71	17	20.64	0.24287
72	17	14.44	0.63603
73	17	20.40	0.25408
74	17	11.73	0.81645
75	17	13.40	0.70901
76	17	17.87	0.39687
77	17	19.42	0.30523
78	17	16.14	0.51399
79	17	18.97	0.33049
80	17	12.61	0.76183
81	17	17.84	0.39915
82	17	16.24	0.50659
83	17	16.76	0.47073
84	17	10.99	0.85718
85	17	20.50	0.24933
86	17	25.42	0.08564
87	17	21.87	0.18995
88	17	13.37	0.71142
89	17	19.85	0.28194
90	17	14.73	0.61521
91	17	13.24	0.72030
92	17	13.29	0.71666
93	17	16.49	0.48972
94	17	13.65	0.69136
95	17	21.35	0.21103
96	17	15.37	0.56917
97	17	19.44	0.30410
98	17	15.85	0.53425
99	17	12.50	0.76866
100	17	13.71	0.68728
Combined P-value for all tests (Using KS method)			0.27905

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 is sufficient data.

1.2 Dealer's opening score (from first two cards):

Test No.	DOF	ChiSqr	P-Value
1	17	18.72	0.34471
2	17	23.81	0.12463
3	17	20.11	0.26867
4	17	35.44	0.00545
5	17	19.14	0.32030
6	17	18.72	0.34466
7	17	7.62	0.97397
8	17	18.83	0.33817
9	17	27.36	0.05300
10	17	13.45	0.70540
11	17	17.62	0.41351
12	17	14.90	0.60243

13	17	10.16	0.89663
14	17	16.62	0.48054
15	17	27.80	0.04733
16	17	7.81	0.97046
17	17	20.55	0.24697
18	17	21.67	0.19756
19	17	12.59	0.76321
20	17	21.02	0.22524
21	17	18.40	0.36379
22	17	13.74	0.68543
23	17	29.09	0.03367
24	17	24.56	0.10507
25	17	13.53	0.70019
26	17	12.60	0.76232
27	17	19.81	0.28382
28	17	14.13	0.65764
29	17	19.52	0.29977
30	17	12.86	0.74528
31	17	19.59	0.29577
32	17	16.09	0.51767
33	17	11.46	0.83195
34	17	30.23	0.02474
35	17	19.58	0.29616
36	17	10.18	0.89575
37	17	27.34	0.05328
38	17	20.50	0.24967
39	17	23.81	0.12480
40	17	15.04	0.59240
41	17	20.52	0.24853
42	17	20.44	0.25253
43	17	15.97	0.52615
44	17	9.90	0.90755
45	17	8.65	0.95068
46	17	11.05	0.85413
47	17	14.97	0.59799
48	17	9.14	0.93578
49	17	7.71	0.97235
50	17	18.22	0.37513
51	17	18.53	0.35631
52	17	22.77	0.15687
53	17	20.77	0.23691
54	17	12.92	0.74120
55	17	17.38	0.42870
56	17	16.36	0.49877
57	17	12.41	0.77488
58	17	21.27	0.21438
59	17	18.62	0.35085
60	17	18.05	0.38577
61	17	24.37	0.10963

62	17	19.46	0.30298
63	17	15.67	0.54765
64	17	18.40	0.36414
65	17	14.37	0.64077
66	17	12.05	0.79688
67	17	11.58	0.82502
68	17	11.21	0.84525
69	17	23.40	0.13670
70	17	35.09	0.00605
71	17	21.24	0.21569
72	17	15.14	0.58537
73	17	31.40	0.01786
74	17	22.13	0.17989
75	17	17.58	0.41573
76	17	19.43	0.30456
77	17	14.99	0.59655
78	17	28.14	0.04330
79	17	17.80	0.40157
80	17	11.11	0.85089
81	17	20.14	0.26713
82	17	15.57	0.55449
83	17	16.02	0.52221
84	17	18.33	0.36861
85	17	14.44	0.63605
86	17	17.68	0.40923
87	17	16.81	0.46760
88	17	22.95	0.15083
89	17	25.78	0.07851
90	17	17.46	0.42361
91	17	11.86	0.80865
92	17	20.24	0.26191
93	17	20.55	0.24707
94	17	25.44	0.08538
95	17	23.13	0.14513
96	17	16.91	0.46063
97	17	30.83	0.02092
98	17	8.90	0.94323
99	17	21.90	0.18842
100	17	15.82	0.53633
Combined P-value for all tests (Using KS method)			0.03320

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 is 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	54.19	0.31762
2	50	41.76	0.79010
3	50	51.53	0.41353

4	50	47.33	0.58120
5	50	52.46	0.37870
6	50	46.80	0.60240
7	50	41.80	0.78881
8	50	64.60	0.08031
9	50	44.11	0.70779
10	50	46.23	0.62554
11	50	51.47	0.41581
12	50	68.81	0.03995
13	50	69.89	0.03304
14	50	60.02	0.15678
15	50	59.73	0.16317
16	50	37.77	0.89829
17	50	64.09	0.08689
18	50	49.08	0.51031
19	50	46.25	0.62470
20	50	32.70	0.97223
21	50	72.46	0.02058
22	50	48.98	0.51432
23	50	41.60	0.79523
24	50	54.45	0.30914
25	50	37.40	0.90595
26	50	62.06	0.11781
27	50	46.90	0.59869
28	50	50.85	0.44003
29	50	71.45	0.02487
30	50	48.51	0.53333
31	50	30.28	0.98763
32	50	46.93	0.59744
33	50	54.33	0.31284
34	50	55.68	0.26954
35	50	42.64	0.76060
36	50	65.89	0.06531
37	50	38.35	0.88530
38	50	54.49	0.30771
39	50	33.24	0.96726
40	50	46.40	0.61851
41	50	77.61	0.00743
42	50	42.62	0.76138
43	50	49.84	0.47970
44	50	46.08	0.63129
45	50	36.50	0.92326
46	50	58.64	0.18820
47	50	38.25	0.88763
48	50	72.74	0.01951
49	50	41.55	0.79687
50	50	58.59	0.18932
51	50	49.26	0.50321
52	50	51.34	0.42111

53	50	45.42	0.65727
54	50	39.80	0.84866
55	50	53.70	0.33462
56	50	42.94	0.74999
57	50	57.85	0.20804
58	50	53.18	0.35270
59	50	59.83	0.16082
60	50	58.67	0.18753
61	50	50.09	0.46973
62	50	34.32	0.95556
63	50	45.39	0.65846
64	50	68.16	0.04473
65	50	53.00	0.35904
66	50	51.58	0.41177
67	50	45.32	0.66121
68	50	65.10	0.07423
69	50	56.74	0.23824
70	50	65.54	0.06918
71	50	62.84	0.10501
72	50	38.65	0.87815
73	50	36.31	0.92660
74	50	57.42	0.21945
75	50	54.20	0.31742
76	50	47.39	0.57873
77	50	44.13	0.70688
78	50	48.48	0.53448
79	50	51.46	0.41639
80	50	37.57	0.90257
81	50	59.79	0.16180
82	50	34.21	0.95697
83	50	34.40	0.95460
84	50	49.63	0.48801
85	50	61.94	0.11991
86	50	49.89	0.47784
87	50	55.42	0.27765
88	50	53.58	0.33876
89	50	48.72	0.52500
90	50	48.87	0.51873
91	50	41.33	0.80383
92	50	44.42	0.69593
93	50	62.65	0.10797
94	50	41.20	0.80786
95	50	54.31	0.31381
96	50	37.55	0.90300
97	50	61.56	0.12655
98	50	65.74	0.06690
99	50	47.35	0.58048
100	50	64.87	0.07687
Combined P-value for all tests			0.84412

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 is 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	11.51	0.48566
2	12	12.44	0.41102
3	12	8.79	0.72066
4	12	5.70	0.93023
5	12	13.17	0.35691
6	12	9.15	0.69040
7	12	12.78	0.38487
8	12	7.04	0.85473
9	12	18.56	0.09981
10	12	12.49	0.40751
11	12	18.86	0.09206
12	12	6.08	0.91176
13	12	7.92	0.79147
14	12	5.93	0.91967
15	12	10.34	0.58613
16	12	6.89	0.86464
17	12	18.10	0.11273
18	12	19.90	0.06895
19	12	17.05	0.14781
20	12	10.02	0.61398
21	12	5.37	0.94465
22	12	20.47	0.05874
23	12	11.62	0.47692
24	12	14.25	0.28477
25	12	8.94	0.70804
26	12	13.07	0.36372
27	12	11.32	0.50171
28	12	7.16	0.84657
29	12	16.04	0.18946
30	12	19.24	0.08301
31	12	20.50	0.05815
32	12	7.45	0.82616
33	12	16.39	0.17405
34	12	7.36	0.83329
35	12	10.66	0.55787
36	12	8.12	0.77587
37	12	11.86	0.45720

38	12	16.59	0.16589
39	12	7.71	0.80743
40	12	12.47	0.40908
41	12	13.30	0.34738
42	12	16.88	0.15435
43	12	6.77	0.87259
44	12	9.74	0.63842
45	12	13.24	0.35182
46	12	10.80	0.54597
47	12	9.32	0.67561
48	12	9.52	0.65838
49	12	5.42	0.94259
50	12	9.05	0.69845
51	12	12.59	0.39918
52	12	5.24	0.94960
53	12	13.23	0.35226
54	12	11.38	0.49671
55	12	7.58	0.81714
56	12	13.72	0.31927
57	12	13.86	0.30958
58	12	14.79	0.25324
59	12	15.03	0.23987
60	12	9.29	0.67834
61	12	17.31	0.13824
62	12	10.27	0.59228
63	12	13.47	0.33561
64	12	14.09	0.29502
65	12	6.87	0.86626
66	12	10.48	0.57420
67	12	9.17	0.68839
68	12	8.38	0.75446
69	12	14.63	0.26219
70	12	12.34	0.41866
71	12	7.93	0.79062
72	12	12.23	0.42729
73	12	2.92	0.99611
74	12	7.17	0.84601
75	12	9.08	0.69627
76	12	7.77	0.80304
77	12	4.53	0.97194
78	12	12.40	0.41448
79	12	17.72	0.12439
80	12	14.81	0.25202
81	12	10.80	0.54619
82	12	4.97	0.95892
83	12	13.45	0.33689
84	12	10.97	0.53152
85	12	16.98	0.15031
86	12	9.43	0.66599

87	12	17.60	0.12848
88	12	13.02	0.36773
89	12	10.19	0.59906
90	12	2.37	0.99860
91	12	5.91	0.92069
92	12	26.49	0.00914
93	12	8.95	0.70717
94	12	2.93	0.99604
95	12	15.09	0.23642
96	12	6.84	0.86820
97	12	19.62	0.07471
98	12	12.21	0.42929
99	12	10.47	0.57458
100	12	9.70	0.64266
Combined P-value for all tests (Using KS method)			0.76883

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 is sufficient data.

2.2 Blackjack rank statistics for all dealer cards:

Test No.	DOF	ChiSqr	P-Value
1	12	10.83	0.54317
2	12	8.06	0.78023
3	12	11.41	0.49393
4	12	9.47	0.66249
5	12	13.30	0.34727
6	12	14.59	0.26435
7	12	12.63	0.39615
8	12	20.67	0.05538
9	12	11.59	0.47944
10	12	11.13	0.51750
11	12	19.98	0.06745
12	12	10.51	0.57162
13	12	11.98	0.44717
14	12	7.05	0.85397
15	12	12.53	0.40382
16	12	12.66	0.39394
17	12	14.30	0.28224
18	12	9.49	0.66050
19	12	15.32	0.22452
20	12	7.61	0.81484
21	12	25.02	0.01471
22	12	3.90	0.98522
23	12	6.27	0.90202
24	12	4.96	0.95919
25	12	13.92	0.30609
26	12	18.15	0.11122
27	12	6.72	0.87539
28	12	12.32	0.42023
29	12	7.28	0.83844
30	12	7.07	0.85312
31	12	4.88	0.96186
32	12	12.97	0.37145

33	12	8.59	0.73775
34	12	18.74	0.09511
35	12	13.11	0.36122
36	12	11.95	0.44957
37	12	10.66	0.55854
38	12	9.60	0.65126
39	12	10.35	0.58541
40	12	14.25	0.28492
41	12	6.91	0.86341
42	12	10.99	0.52942
43	12	14.52	0.26856
44	12	6.92	0.86304
45	12	14.64	0.26184
46	12	9.15	0.68979
47	12	8.64	0.73327
48	12	16.52	0.16867
49	12	14.65	0.26092
50	12	8.42	0.75150
51	12	13.55	0.33051
52	12	3.99	0.98367
53	12	9.96	0.61921
54	12	11.92	0.45244
55	12	14.33	0.28027
56	12	7.15	0.84781
57	12	11.37	0.49722
58	12	9.63	0.64810
59	12	20.90	0.05189
60	12	16.15	0.18433
61	12	5.98	0.91700
62	12	9.85	0.62950
63	12	15.17	0.23231
64	12	12.27	0.42390
65	12	9.75	0.63778
66	12	18.26	0.10802
67	12	10.56	0.56654
68	12	14.32	0.28065
69	12	13.16	0.35759
70	12	6.39	0.89537
71	12	19.31	0.08132
72	12	10.60	0.56374
73	12	8.10	0.77734
74	12	12.33	0.41972
75	12	8.60	0.73682
76	12	6.81	0.86962
77	12	4.37	0.97588
78	12	7.62	0.81426
79	12	11.77	0.46452
80	12	9.83	0.63044
81	12	15.64	0.20806
82	12	16.46	0.17091
83	12	13.54	0.33101
84	12	10.08	0.60872
85	12	8.12	0.77597
86	12	6.52	0.88764
87	12	9.06	0.69744
88	12	10.86	0.54063

89	12	7.82	0.79895
90	12	8.77	0.72253
91	12	8.89	0.71201
92	12	8.33	0.75859
93	12	12.07	0.44000
94	12	19.82	0.07060
95	12	19.65	0.07401
96	12	5.76	0.92779
97	12	14.64	0.26168
98	12	3.57	0.99007
99	12	19.04	0.08762
100	12	15.23	0.22889
Combined P-value for all tests (Using KS method)			0.51229

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 is sufficient data.

4. Summary of the analysis of blackjack tests

The Blackjack cards analysis is completed 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 an indication for statistical randomness.

Combination of p-values using Holm's Method		
Test	P-Value	P-Adjusted
Opening Score (Player)	0.27905	1.00000
Opening Score (Dealer)	0.03320	0.16601
Dealer's Final Score	0.84412	1.00000
Player Cards Rank	0.76883	1.00000
Dealer Cards Rank	0.51229	1.00000
Combined P-Value using Holm's Method		0.16601

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 decks 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: 20 August 2024

Signed:



Alvin Rizaldi
Chief Executive Officer
iTech Labs Australia
Date: 20 August 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.

