



Blackjack Cards Analysis – March 2024

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **March 01, 2024, to March 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	11.56	0.82612
2	17	26.76	0.06162
3	17	9.53	0.92200
4	17	24.31	0.11120
5	17	21.46	0.20634
6	17	12.34	0.77918
7	17	14.20	0.65292
8	17	10.84	0.86465
9	17	16.48	0.49043
10	17	20.44	0.25220
11	17	16.15	0.51351
12	17	17.96	0.39123
13	17	12.25	0.78466
14	17	27.01	0.05799
15	17	31.32	0.01826
16	17	14.83	0.60789
17	17	20.08	0.27034
18	17	26.82	0.06073
19	17	16.74	0.47213
20	17	14.08	0.66110
21	17	16.35	0.49941

22	17	12.71	0.75549
23	17	9.50	0.92335
24	17	13.77	0.68329
25	17	21.22	0.21648
26	17	15.84	0.53524
27	17	11.61	0.82329
28	17	15.35	0.57005
29	17	10.26	0.89251
30	17	14.72	0.61592
31	17	26.73	0.06221
32	17	16.70	0.47471
33	17	9.68	0.91664
34	17	11.06	0.85322
35	17	13.31	0.71503
36	17	12.67	0.75825
37	17	19.75	0.28718
38	17	18.24	0.37413
39	17	14.77	0.61235
40	17	18.95	0.33140
41	17	15.90	0.53081
42	17	23.46	0.13500
43	17	15.97	0.52586
44	17	11.92	0.80470
45	17	18.33	0.36862
46	17	12.35	0.77834
47	17	16.62	0.48008
48	17	22.76	0.15722
49	17	19.89	0.27981
50	17	11.49	0.83015
51	17	13.79	0.68178
52	17	12.03	0.79820
53	17	24.04	0.11840
54	17	13.90	0.67382
55	17	13.09	0.73037
56	17	39.87	0.00135
57	17	22.02	0.18385
58	17	9.01	0.93988
59	17	9.19	0.93399
60	17	16.90	0.46135
61	17	23.32	0.13912
62	17	13.31	0.71538
63	17	19.29	0.31237
64	17	25.37	0.08663
65	17	16.20	0.50968
66	17	10.31	0.89015
67	17	8.35	0.95853
68	17	18.25	0.37313
69	17	13.86	0.67725
70	17	14.55	0.62790

71	17	16.07	0.51923
72	17	11.29	0.84107
73	17	25.80	0.07812
74	17	15.86	0.53376
75	17	19.41	0.30528
76	17	17.96	0.39124
77	17	4.75	0.99838
78	17	12.93	0.74118
79	17	22.36	0.17143
80	17	13.45	0.70542
81	17	12.50	0.76877
82	17	16.59	0.48221
83	17	18.34	0.36782
84	17	10.42	0.88512
85	17	18.09	0.38305
86	17	12.60	0.76227
87	17	28.38	0.04065
88	17	16.64	0.47883
89	17	9.25	0.93203
90	17	18.62	0.35053
91	17	20.41	0.25362
92	17	7.48	0.97649
93	17	16.60	0.48165
94	17	15.97	0.52586
95	17	16.32	0.50105
96	17	8.82	0.94567
97	17	5.24	0.99701
98	17	12.91	0.74205
99	17	20.70	0.23984
100	17	10.18	0.89589
Combined P-value for all tests (Using KS method)			0.15131

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	16.52	0.48750
2	17	18.98	0.32989
3	17	31.30	0.01838
4	17	15.55	0.55583
5	17	28.38	0.04070
6	17	11.74	0.81575
7	17	27.48	0.05143
8	17	13.91	0.67327
9	17	15.82	0.53673
10	17	12.26	0.78402
11	17	11.70	0.81779
12	17	15.11	0.58731

13	17	13.84	0.67828
14	17	27.98	0.04521
15	17	11.79	0.81267
16	17	19.14	0.32040
17	17	13.15	0.72628
18	17	26.89	0.05964
19	17	11.20	0.84599
20	17	16.74	0.47189
21	17	6.36	0.99044
22	17	14.17	0.65516
23	17	17.81	0.40101
24	17	20.34	0.25702
25	17	25.90	0.07629
26	17	17.08	0.44864
27	17	25.46	0.08481
28	17	10.10	0.89936
29	17	9.78	0.91254
30	17	21.01	0.22607
31	17	17.80	0.40160
32	17	19.52	0.29945
33	17	16.18	0.51117
34	17	10.65	0.87400
35	17	7.48	0.97648
36	17	14.08	0.66149
37	17	17.70	0.40768
38	17	32.75	0.01213
39	17	11.21	0.84527
40	17	13.16	0.72540
41	17	15.71	0.54422
42	17	17.98	0.39004
43	17	12.69	0.75673
44	17	20.19	0.26445
45	17	13.97	0.66889
46	17	13.40	0.70917
47	17	27.10	0.05661
48	17	22.25	0.17531
49	17	18.55	0.35523
50	17	17.01	0.45342
51	17	17.46	0.42374
52	17	12.78	0.75106
53	17	12.15	0.79111
54	17	14.32	0.64444
55	17	19.36	0.30811
56	17	21.74	0.19480
57	17	17.20	0.44068
58	17	15.43	0.56447
59	17	13.63	0.69277
60	17	6.72	0.98692
61	17	11.61	0.82329

62	17	13.04	0.73333
63	17	20.14	0.26712
64	17	14.57	0.62675
65	17	20.82	0.23450
66	17	20.71	0.23960
67	17	9.86	0.90919
68	17	18.83	0.33819
69	17	17.46	0.42352
70	17	17.37	0.42950
71	17	16.58	0.48317
72	17	21.52	0.20382
73	17	14.09	0.66055
74	17	26.66	0.06317
75	17	28.68	0.03756
76	17	16.06	0.51945
77	17	20.22	0.26314
78	17	11.05	0.85397
79	17	15.51	0.55911
80	17	9.12	0.93653
81	17	14.37	0.64097
82	17	15.50	0.55967
83	17	30.24	0.02467
84	17	18.70	0.34592
85	17	23.76	0.12603
86	17	12.61	0.76200
87	17	8.56	0.95300
88	17	31.24	0.01864
89	17	19.46	0.30259
90	17	20.94	0.22910
91	17	19.51	0.29984
92	17	20.58	0.24583
93	17	14.37	0.64059
94	17	24.83	0.09861
95	17	16.43	0.49380
96	17	18.84	0.33768
97	17	15.11	0.58772
98	17	20.51	0.24902
99	17	20.08	0.27025
100	17	26.76	0.06168
Combined P-value for all tests (Using KS method)			0.94649

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	61.55	0.12679
2	50	61.63	0.12532
3	50	54.09	0.32118

4	50	49.40	0.49724
5	50	57.39	0.22035
6	50	48.93	0.51643
7	50	34.62	0.95186
8	50	47.46	0.57597
9	50	51.02	0.43346
10	50	60.43	0.14836
11	50	44.92	0.67681
12	50	93.64	0.00018
13	50	55.96	0.26110
14	50	42.17	0.77641
15	50	59.05	0.17842
16	50	40.45	0.83030
17	50	46.36	0.62036
18	50	50.06	0.47110
19	50	50.86	0.43964
20	50	49.54	0.49184
21	50	57.89	0.20712
22	50	58.74	0.18581
23	50	68.66	0.04101
24	50	51.58	0.41175
25	50	46.71	0.60630
26	50	58.27	0.19732
27	50	53.07	0.35681
28	50	49.90	0.47734
29	50	74.21	0.01470
30	50	40.89	0.81741
31	50	51.30	0.42235
32	50	34.33	0.95551
33	50	33.99	0.95942
34	50	68.20	0.04443
35	50	65.70	0.06738
36	50	42.21	0.77528
37	50	52.14	0.39065
38	50	63.77	0.09132
39	50	60.61	0.14467
40	50	67.38	0.05104
41	50	48.16	0.54734
42	50	39.69	0.85164
43	50	47.84	0.56048
44	50	49.68	0.48625
45	50	59.46	0.16898
46	50	67.20	0.05266
47	50	49.57	0.49065
48	50	56.05	0.25852
49	50	65.99	0.06427
50	50	63.67	0.09261
51	50	40.55	0.82738
52	50	45.67	0.64751

53	50	48.46	0.53517
54	50	41.46	0.79980
55	50	66.05	0.06366
56	50	40.61	0.82558
57	50	52.42	0.38037
58	50	61.13	0.13446
59	50	65.83	0.06603
60	50	43.84	0.71753
61	50	39.50	0.85680
62	50	62.77	0.10615
63	50	55.34	0.28028
64	50	79.10	0.00543
65	50	53.85	0.32933
66	50	68.00	0.04597
67	50	46.47	0.61589
68	50	57.83	0.20849
69	50	56.76	0.23772
70	50	35.78	0.93521
71	50	54.75	0.29915
72	50	59.98	0.15776
73	50	39.32	0.86148
74	50	40.57	0.82682
75	50	51.51	0.41428
76	50	54.88	0.29499
77	50	58.72	0.18638
78	50	36.99	0.91414
79	50	53.81	0.33053
80	50	43.29	0.73748
81	50	66.21	0.06198
82	50	33.45	0.96521
83	50	40.64	0.82474
84	50	45.13	0.66881
85	50	46.51	0.61439
86	50	59.26	0.17352
87	50	45.53	0.65317
88	50	52.64	0.37234
89	50	33.44	0.96532
90	50	60.26	0.15182
91	50	63.92	0.08922
92	50	82.69	0.00248
93	50	35.48	0.93989
94	50	48.93	0.51643
95	50	47.51	0.57371
96	50	50.42	0.45692
97	50	56.85	0.23501
98	50	58.30	0.19665
99	50	45.63	0.64933
100	50	65.39	0.07077
Combined P-value for all tests			0.05508

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	14.36	0.27842
2	12	5.90	0.92080
3	12	4.42	0.97472
4	12	9.87	0.62742
5	12	14.75	0.25522
6	12	10.03	0.61305
7	12	11.16	0.51556
8	12	6.56	0.88540
9	12	11.81	0.46079
10	12	16.64	0.16373
11	12	7.23	0.84193
12	12	18.05	0.11409
13	12	13.11	0.36080
14	12	24.44	0.01773
15	12	18.43	0.10318
16	12	15.44	0.21845
17	12	7.25	0.84058
18	12	9.94	0.62141
19	12	9.30	0.67734
20	12	5.27	0.94835
21	12	11.11	0.51911
22	12	12.51	0.40563
23	12	10.20	0.59876
24	12	11.81	0.46096
25	12	10.58	0.56547
26	12	4.24	0.97873
27	12	3.83	0.98639
28	12	12.68	0.39243
29	12	7.55	0.81935
30	12	8.92	0.70971
31	12	9.12	0.69256
32	12	22.34	0.03386
33	12	15.81	0.19999
34	12	12.37	0.41653
35	12	4.84	0.96304
36	12	7.76	0.80376
37	12	16.97	0.15078

38	12	6.06	0.91312
39	12	8.25	0.76544
40	12	17.66	0.12654
41	12	18.54	0.10022
42	12	19.42	0.07879
43	12	10.20	0.59876
44	12	14.82	0.25144
45	12	12.21	0.42932
46	12	12.63	0.39652
47	12	11.04	0.52543
48	12	9.84	0.62973
49	12	24.74	0.01609
50	12	17.20	0.14236
51	12	7.70	0.80804
52	12	19.84	0.07017
53	12	11.21	0.51126
54	12	7.13	0.84900
55	12	20.66	0.05566
56	12	24.16	0.01935
57	12	12.62	0.39694
58	12	17.32	0.13796
59	12	19.34	0.08073
60	12	14.56	0.26617
61	12	9.50	0.65949
62	12	5.92	0.92008
63	12	16.44	0.17207
64	12	12.47	0.40835
65	12	7.83	0.79813
66	12	8.78	0.72178
67	12	13.30	0.34752
68	12	7.34	0.83420
69	12	7.95	0.78925
70	12	11.53	0.48424
71	12	10.24	0.59481
72	12	10.63	0.56118
73	12	9.45	0.66443
74	12	15.66	0.20716
75	12	7.66	0.81115
76	12	14.67	0.25976
77	12	9.81	0.63274
78	12	14.66	0.26041
79	12	8.44	0.74964
80	12	5.18	0.95183
81	12	3.74	0.98770
82	12	8.82	0.71798
83	12	3.69	0.98836
84	12	17.18	0.14284
85	12	3.49	0.99096
86	12	11.72	0.46858

87	12	12.65	0.39516
88	12	10.69	0.55551
89	12	21.18	0.04786
90	12	15.06	0.23814
91	12	5.66	0.93237
92	12	8.65	0.73228
93	12	7.78	0.80187
94	12	12.69	0.39214
95	12	18.37	0.10493
96	12	10.49	0.57323
97	12	9.55	0.65509
98	12	17.82	0.12115
99	12	11.86	0.45664
100	12	20.40	0.05987
Combined P-value for all tests (Using KS method)			0.94298

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	10.18	0.60000
2	12	10.86	0.54136
3	12	10.38	0.58282
4	12	16.19	0.18250
5	12	10.37	0.58359
6	12	9.04	0.69937
7	12	12.30	0.42224
8	12	20.64	0.05594
9	12	9.33	0.67422
10	12	11.18	0.51354
11	12	19.30	0.08159
12	12	5.45	0.94103
13	12	23.60	0.02301
14	12	12.26	0.42473
15	12	11.22	0.50991
16	12	12.77	0.38563
17	12	7.73	0.80581
18	12	9.64	0.64789
19	12	9.97	0.61850
20	12	23.26	0.02559
21	12	13.03	0.36678
22	12	8.23	0.76706
23	12	14.61	0.26330
24	12	7.24	0.84168
25	12	13.90	0.30687
26	12	12.19	0.43021
27	12	12.48	0.40772
28	12	2.91	0.99617
29	12	9.26	0.68075
30	12	17.09	0.14633
31	12	19.03	0.08779
32	12	11.08	0.52239

33	12	6.25	0.90282
34	12	11.51	0.48591
35	12	6.91	0.86381
36	12	4.71	0.96703
37	12	8.23	0.76652
38	12	23.05	0.02728
39	12	11.61	0.47760
40	12	6.14	0.90894
41	12	15.89	0.19654
42	12	21.18	0.04780
43	12	10.50	0.57254
44	12	21.29	0.04629
45	12	12.20	0.42937
46	12	14.54	0.26779
47	12	26.90	0.00800
48	12	12.19	0.43073
49	12	11.30	0.50368
50	12	12.30	0.42179
51	12	10.54	0.56828
52	12	9.91	0.62353
53	12	15.20	0.23065
54	12	9.14	0.69056
55	12	15.68	0.20640
56	12	10.78	0.54804
57	12	13.76	0.31641
58	12	9.37	0.67101
59	12	15.16	0.23271
60	12	14.83	0.25092
61	12	13.17	0.35665
62	12	7.64	0.81293
63	12	15.57	0.21161
64	12	16.53	0.16822
65	12	6.81	0.86991
66	12	13.32	0.34614
67	12	13.58	0.32852
68	12	7.79	0.80111
69	12	8.02	0.78345
70	12	5.77	0.92716
71	12	10.66	0.55820
72	12	13.04	0.36608
73	12	8.90	0.71143
74	12	20.49	0.05841
75	12	14.61	0.26335
76	12	8.98	0.70498
77	12	5.44	0.94170
78	12	9.64	0.64715
79	12	15.47	0.21685
80	12	14.08	0.29574
81	12	13.04	0.36650
82	12	18.72	0.09555
83	12	15.40	0.22034
84	12	20.19	0.06353
85	12	8.71	0.72731
86	12	6.96	0.85996
87	12	24.01	0.02030
88	12	21.01	0.05029

89	12	11.55	0.48221
90	12	8.29	0.76241
91	12	22.81	0.02936
92	12	10.85	0.54195
93	12	9.05	0.69861
94	12	6.16	0.90794
95	12	13.49	0.33431
96	12	16.54	0.16754
97	12	8.52	0.74366
98	12	14.16	0.29032
99	12	8.34	0.75838
100	12	13.69	0.32083
Combined P-value for all tests (Using KS method)			0.81080

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)	0.15131	0.60524
Opening Score (Dealer)	0.94649	1.00000
Dealer's Final Score	0.05508	0.27539
Player Cards Rank	0.94298	1.00000
Dealer Cards Rank	0.81080	1.00000
Combined P-Value using Holm's Method		0.27539

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: 22 April 2024

Signed:



Alvin Rizaldi
Chief Executive Officer
iTech Labs Australia
Date: 22 April 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.