



Blackjack Cards Analysis – April 2024

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **April 01, 2024, to April 30, 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	6.93	0.98450
2	17	11.58	0.82466
3	17	15.32	0.57262
4	17	17.46	0.42345
5	17	16.16	0.51237
6	17	14.24	0.65019
7	17	19.96	0.27629
8	17	15.32	0.57247
9	17	10.63	0.87492
10	17	16.32	0.50135
11	17	17.40	0.42782
12	17	11.66	0.82014
13	17	17.87	0.39708
14	17	7.57	0.97496
15	17	19.63	0.29379
16	17	15.13	0.58592
17	17	20.50	0.24938
18	17	15.12	0.58672
19	17	29.36	0.03131
20	17	9.84	0.91006
21	17	11.96	0.80253

22	17	10.99	0.85683
23	17	14.69	0.61805
24	17	23.01	0.14877
25	17	13.40	0.70899
26	17	13.13	0.72764
27	17	24.76	0.10015
28	17	16.24	0.50704
29	17	9.32	0.92980
30	17	16.06	0.51972
31	17	5.04	0.99764
32	17	17.97	0.39060
33	17	17.41	0.42673
34	17	19.87	0.28111
35	17	19.39	0.30660
36	17	16.82	0.46667
37	17	14.90	0.60302
38	17	16.24	0.50682
39	17	26.26	0.06988
40	17	19.30	0.31153
41	17	20.84	0.23364
42	17	19.64	0.29323
43	17	18.95	0.33146
44	17	21.07	0.22316
45	17	15.35	0.56999
46	17	19.42	0.30471
47	17	27.70	0.04854
48	17	16.56	0.48440
49	17	10.84	0.86457
50	17	19.72	0.28856
51	17	15.62	0.55090
52	17	13.41	0.70826
53	17	12.30	0.78195
54	17	14.37	0.64060
55	17	11.07	0.85266
56	17	18.43	0.36246
57	17	14.39	0.63922
58	17	16.84	0.46532
59	17	16.24	0.50701
60	17	14.93	0.60083
61	17	13.30	0.71570
62	17	14.37	0.64057
63	17	23.11	0.14561
64	17	17.06	0.44999
65	17	12.48	0.77001
66	17	13.60	0.69523
67	17	16.90	0.46133
68	17	14.50	0.63133
69	17	14.96	0.59804
70	17	21.25	0.21516

71	17	19.98	0.27517
72	17	14.71	0.61621
73	17	13.14	0.72703
74	17	11.17	0.84770
75	17	18.40	0.36434
76	17	20.19	0.26470
77	17	30.73	0.02153
78	17	17.70	0.40826
79	17	14.50	0.63146
80	17	11.79	0.81252
81	17	13.74	0.68556
82	17	21.43	0.20765
83	17	17.17	0.44307
84	17	12.06	0.79657
85	17	8.85	0.94483
86	17	20.12	0.26824
87	17	16.01	0.52300
88	17	16.13	0.51447
89	17	17.54	0.41871
90	17	25.51	0.08381
91	17	25.09	0.09269
92	17	17.59	0.41494
93	17	15.86	0.53355
94	17	12.03	0.79862
95	17	12.68	0.75720
96	17	15.29	0.57424
97	17	17.39	0.42800
98	17	19.07	0.32446
99	17	19.33	0.30967
100	17	11.04	0.85435
Combined P-value for all tests (Using KS method)			0.08218

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	16.20	0.50946
2	17	8.57	0.95267
3	17	16.26	0.50527
4	17	10.73	0.87034
5	17	17.20	0.44120
6	17	13.14	0.72663
7	17	16.56	0.48489
8	17	23.37	0.13769
9	17	10.20	0.89509
10	17	13.58	0.69666
11	17	16.43	0.49365
12	17	13.14	0.72684

13	17	18.11	0.38184
14	17	12.89	0.74379
15	17	21.20	0.21741
16	17	12.06	0.79652
17	17	13.53	0.70012
18	17	9.80	0.91198
19	17	21.22	0.21661
20	17	18.45	0.36095
21	17	18.44	0.36143
22	17	13.28	0.71756
23	17	16.99	0.45494
24	17	10.87	0.86320
25	17	17.49	0.42153
26	17	14.75	0.61336
27	17	21.96	0.18629
28	17	15.28	0.57550
29	17	9.21	0.93330
30	17	26.56	0.06478
31	17	19.10	0.32265
32	17	12.19	0.78863
33	17	15.99	0.52458
34	17	6.92	0.98453
35	17	13.51	0.70161
36	17	20.30	0.25925
37	17	15.47	0.56200
38	17	15.54	0.55688
39	17	18.84	0.33780
40	17	21.11	0.22124
41	17	18.75	0.34287
42	17	17.47	0.42285
43	17	17.93	0.39334
44	17	17.75	0.40459
45	17	20.05	0.27151
46	17	10.89	0.86227
47	17	26.89	0.05974
48	17	19.81	0.28391
49	17	18.14	0.38032
50	17	16.93	0.45902
51	17	23.26	0.14110
52	17	17.69	0.40877
53	17	19.89	0.27969
54	17	18.95	0.33165
55	17	12.42	0.77421
56	17	17.06	0.45031
57	17	21.14	0.22007
58	17	16.31	0.50183
59	17	5.55	0.99572
60	17	13.73	0.68624
61	17	12.38	0.77667

62	17	9.75	0.91376
63	17	11.64	0.82118
64	17	19.23	0.31547
65	17	12.01	0.79973
66	17	14.32	0.64443
67	17	10.71	0.87136
68	17	22.31	0.17308
69	17	18.08	0.38368
70	17	12.97	0.73842
71	17	17.57	0.41615
72	17	14.14	0.65752
73	17	17.32	0.43299
74	17	18.11	0.38189
75	17	17.94	0.39278
76	17	16.26	0.50524
77	17	11.18	0.84694
78	17	19.98	0.27500
79	17	27.36	0.05300
80	17	20.81	0.23487
81	17	19.34	0.30951
82	17	16.75	0.47111
83	17	21.25	0.21523
84	17	17.42	0.42628
85	17	20.77	0.23685
86	17	11.23	0.84446
87	17	16.83	0.46625
88	17	10.39	0.88658
89	17	25.42	0.08564
90	17	17.64	0.41172
91	17	14.99	0.59599
92	17	9.64	0.91818
93	17	12.58	0.76364
94	17	27.16	0.05582
95	17	14.17	0.65508
96	17	24.32	0.11090
97	17	15.76	0.54113
98	17	15.57	0.55438
99	17	21.81	0.19195
100	17	17.94	0.39275
Combined P-value for all tests (Using KS method)			0.20580

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	50.91	0.43745
2	50	60.26	0.15181
3	50	45.77	0.64363

4	50	39.05	0.86846
5	50	43.17	0.74194
6	50	55.28	0.28216
7	50	57.18	0.22606
8	50	42.90	0.75145
9	50	34.18	0.95727
10	50	39.94	0.84502
11	50	36.80	0.91763
12	50	39.97	0.84404
13	50	59.88	0.15980
14	50	53.89	0.32787
15	50	65.85	0.06581
16	50	54.87	0.29534
17	50	54.77	0.29861
18	50	41.60	0.79530
19	50	50.76	0.44362
20	50	48.25	0.54387
21	50	56.63	0.24151
22	50	44.05	0.70973
23	50	43.55	0.72809
24	50	57.42	0.21951
25	50	42.38	0.76957
26	50	43.29	0.73764
27	50	42.02	0.78162
28	50	40.10	0.84055
29	50	39.38	0.86000
30	50	63.19	0.09971
31	50	46.29	0.62306
32	50	60.66	0.14363
33	50	40.11	0.84009
34	50	41.87	0.78637
35	50	48.39	0.53835
36	50	59.66	0.16466
37	50	49.59	0.48993
38	50	51.20	0.42650
39	50	50.03	0.47210
40	50	48.06	0.55169
41	50	57.77	0.21013
42	50	64.69	0.07913
43	50	37.91	0.89517
44	50	64.31	0.08402
45	50	35.84	0.93432
46	50	58.59	0.18936
47	50	59.04	0.17875
48	50	39.69	0.85180
49	50	44.73	0.68415
50	50	41.63	0.79433
51	50	58.95	0.18088
52	50	44.19	0.70459

53	50	39.34	0.86109
54	50	38.38	0.88457
55	50	68.54	0.04186
56	50	36.35	0.92589
57	50	47.67	0.56723
58	50	43.79	0.71961
59	50	64.70	0.07903
60	50	53.53	0.34037
61	50	59.30	0.17260
62	50	50.24	0.46400
63	50	41.58	0.79593
64	50	51.17	0.42768
65	50	39.70	0.85156
66	50	47.64	0.56875
67	50	48.27	0.54302
68	50	34.03	0.95899
69	50	33.18	0.96790
70	50	55.69	0.26941
71	50	65.31	0.07171
72	50	45.42	0.65761
73	50	53.31	0.34819
74	50	60.91	0.13864
75	50	52.25	0.38677
76	50	47.91	0.55774
77	50	37.97	0.89399
78	50	52.10	0.39212
79	50	48.64	0.52787
80	50	38.18	0.88924
81	50	54.49	0.30774
82	50	63.72	0.09200
83	50	45.43	0.65693
84	50	34.94	0.94762
85	50	53.39	0.34546
86	50	53.23	0.35100
87	50	60.81	0.14069
88	50	43.14	0.74296
89	50	47.68	0.56705
90	50	65.93	0.06491
91	50	56.68	0.23990
92	50	59.44	0.16951
93	50	44.21	0.70388
94	50	36.65	0.92049
95	50	63.88	0.08973
96	50	39.44	0.85828
97	50	65.54	0.06910
98	50	54.07	0.32180
99	50	41.27	0.80569
100	50	48.66	0.52739
Combined P-value for all tests			0.46571

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	17.63	0.12745
2	12	24.73	0.01615
3	12	11.20	0.51222
4	12	12.61	0.39820
5	12	8.30	0.76128
6	12	15.09	0.23678
7	12	22.33	0.03400
8	12	9.83	0.63121
9	12	10.42	0.57924
10	12	7.71	0.80719
11	12	9.40	0.66862
12	12	11.33	0.50118
13	12	11.07	0.52334
14	12	17.72	0.12437
15	12	12.38	0.41578
16	12	21.91	0.03857
17	12	9.29	0.67764
18	12	14.56	0.26614
19	12	19.98	0.06754
20	12	9.27	0.67951
21	12	7.05	0.85424
22	12	11.28	0.50546
23	12	4.23	0.97887
24	12	10.19	0.59934
25	12	15.40	0.22030
26	12	9.49	0.66101
27	12	20.20	0.06331
28	12	17.87	0.11963
29	12	8.94	0.70843
30	12	13.62	0.32567
31	12	8.02	0.78373
32	12	10.34	0.58615
33	12	3.97	0.98402
34	12	10.65	0.55918
35	12	15.59	0.21072
36	12	12.52	0.40485
37	12	16.09	0.18715

38	12	12.70	0.39137
39	12	10.45	0.57640
40	12	10.06	0.61112
41	12	17.97	0.11651
42	12	7.09	0.85179
43	12	12.61	0.39828
44	12	16.37	0.17474
45	12	9.99	0.61678
46	12	12.73	0.38905
47	12	20.19	0.06358
48	12	12.33	0.41920
49	12	14.06	0.29664
50	12	7.88	0.79449
51	12	8.76	0.72323
52	12	3.72	0.98800
53	12	7.14	0.84805
54	12	20.38	0.06020
55	12	10.22	0.59678
56	12	12.13	0.43549
57	12	10.20	0.59834
58	12	13.44	0.33785
59	12	3.55	0.99026
60	12	6.74	0.87457
61	12	9.52	0.65837
62	12	11.12	0.51903
63	12	15.16	0.23284
64	12	17.91	0.11856
65	12	17.46	0.13298
66	12	10.45	0.57673
67	12	16.81	0.15706
68	12	11.85	0.45769
69	12	4.34	0.97656
70	12	10.28	0.59104
71	12	7.85	0.79670
72	12	10.71	0.55387
73	12	9.06	0.69807
74	12	11.01	0.52796
75	12	8.14	0.77385
76	12	17.40	0.13515
77	12	14.10	0.29455
78	12	9.08	0.69593
79	12	7.95	0.78875
80	12	13.15	0.35841
81	12	2.63	0.99764
82	12	18.76	0.09455
83	12	15.34	0.22344
84	12	14.16	0.29031
85	12	10.65	0.55885
86	12	8.80	0.71995

87	12	12.44	0.41118
88	12	9.55	0.65506
89	12	11.28	0.50469
90	12	18.29	0.10713
91	12	15.02	0.24061
92	12	9.12	0.69249
93	12	15.17	0.23215
94	12	5.11	0.95408
95	12	8.10	0.77763
96	12	9.85	0.62946
97	12	11.55	0.48267
98	12	25.08	0.01447
99	12	11.91	0.45312
100	12	14.21	0.28775
Combined P-value for all tests (Using KS method)			0.58076

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	7.05	0.85413
2	12	6.62	0.88178
3	12	20.82	0.05305
4	12	8.57	0.73949
5	12	8.29	0.76236
6	12	12.94	0.37334
7	12	12.59	0.39954
8	12	3.00	0.99552
9	12	10.56	0.56675
10	12	7.76	0.80389
11	12	6.63	0.88118
12	12	5.82	0.92486
13	12	23.58	0.02318
14	12	6.16	0.90783
15	12	18.13	0.11177
16	12	12.79	0.38465
17	12	14.57	0.26595
18	12	7.93	0.79038
19	12	6.43	0.89284
20	12	13.71	0.31972
21	12	29.60	0.00321
22	12	9.86	0.62782
23	12	9.85	0.62927
24	12	11.97	0.44785
25	12	11.12	0.51833
26	12	23.03	0.02745
27	12	13.21	0.35412
28	12	25.62	0.01215
29	12	7.37	0.83196
30	12	21.75	0.04038
31	12	7.98	0.78664
32	12	11.55	0.48257

33	12	13.75	0.31664
34	12	8.09	0.77791
35	12	18.38	0.10474
36	12	6.47	0.89060
37	12	6.91	0.86324
38	12	9.41	0.66780
39	12	8.13	0.77480
40	12	12.25	0.42619
41	12	13.13	0.35996
42	12	12.30	0.42203
43	12	14.22	0.28705
44	12	5.97	0.91768
45	12	22.70	0.03034
46	12	14.14	0.29155
47	12	16.97	0.15092
48	12	23.59	0.02309
49	12	7.91	0.79248
50	12	10.41	0.58031
51	12	11.52	0.48501
52	12	8.58	0.73830
53	12	10.10	0.60715
54	12	19.78	0.07146
55	12	18.31	0.10660
56	12	15.99	0.19158
57	12	13.19	0.35507
58	12	14.24	0.28582
59	12	6.45	0.89185
60	12	10.68	0.55660
61	12	6.10	0.91074
62	12	9.60	0.65068
63	12	5.72	0.92957
64	12	15.70	0.20540
65	12	9.14	0.69135
66	12	12.68	0.39260
67	12	10.02	0.61414
68	12	8.41	0.75211
69	12	4.81	0.96393
70	12	11.10	0.52013
71	12	7.56	0.81844
72	12	15.90	0.19601
73	12	16.85	0.15548
74	12	13.02	0.36729
75	12	7.73	0.80610
76	12	5.21	0.95046
77	12	5.21	0.95056
78	12	6.29	0.90076
79	12	8.02	0.78360
80	12	22.80	0.02945
81	12	9.99	0.61654
82	12	11.06	0.52379
83	12	15.43	0.21886
84	12	18.26	0.10800
85	12	23.98	0.02047
86	12	19.97	0.06773
87	12	18.04	0.11440
88	12	14.13	0.29224

89	12	16.76	0.15866
90	12	12.98	0.37084
91	12	14.72	0.25689
92	12	23.24	0.02576
93	12	24.36	0.01819
94	12	15.01	0.24072
95	12	19.00	0.08844
96	12	7.82	0.79918
97	12	9.09	0.69509
98	12	9.80	0.63307
99	12	13.53	0.33195
100	12	11.09	0.52148
Combined P-value for all tests (Using KS method)			0.60053

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)	0.08218	0.41092
Opening Score (Dealer)	0.20580	0.82320
Dealer's Final Score	0.46571	1.00000
Player Cards Rank	0.58076	1.00000
Dealer Cards Rank	0.60053	1.00000
Combined P-Value using Holm's Method		0.41092

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: 16 May 2024

Signed:



Alvin Rizaldi
Chief Executive Officer
iTech Labs Australia
Date: 16 May 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.