



Blackjack Cards Analysis – February 2024

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **February 01, 2024 to February 29, 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	16.49	0.48925
2	17	18.31	0.36940
3	17	17.30	0.43418
4	17	22.95	0.15084
5	17	30.45	0.02331
6	17	12.18	0.78920
7	17	23.36	0.13778
8	17	20.82	0.23427
9	17	16.03	0.52148
10	17	18.19	0.37707
11	17	19.05	0.32563
12	17	12.46	0.77168
13	17	13.48	0.70362
14	17	33.34	0.01019
15	17	10.71	0.87115
16	17	11.24	0.84393
17	17	21.49	0.20526
18	17	16.98	0.45545
19	17	9.87	0.90890
20	17	15.74	0.54210
21	17	21.93	0.18724

22	17	11.46	0.83181
23	17	26.30	0.06911
24	17	8.14	0.96352
25	17	8.69	0.94955
26	17	15.68	0.54647
27	17	22.83	0.15478
28	17	7.76	0.97148
29	17	12.10	0.79401
30	17	13.20	0.72276
31	17	8.27	0.96043
32	17	24.75	0.10050
33	17	55.22	0.00001
34	17	12.03	0.79841
35	17	19.31	0.31079
36	17	16.93	0.45886
37	17	18.11	0.38222
38	17	14.53	0.62956
39	17	9.08	0.93760
40	17	14.61	0.62370
41	17	21.23	0.21635
42	17	16.83	0.46620
43	17	20.76	0.23705
44	17	10.99	0.85701
45	17	9.83	0.91074
46	17	14.65	0.62101
47	17	13.79	0.68214
48	17	13.08	0.73060
49	17	14.41	0.63758
50	17	24.79	0.09960
51	17	26.29	0.06931
52	17	26.08	0.07304
53	17	14.57	0.62633
54	17	15.68	0.54629
55	17	11.28	0.84183
56	17	8.61	0.95160
57	17	16.55	0.48489
58	17	13.01	0.73520
59	17	14.61	0.62333
60	17	17.70	0.40809
61	17	15.71	0.54479
62	17	12.67	0.75813
63	17	19.68	0.29076
64	17	10.49	0.88169
65	17	8.65	0.95055
66	17	15.54	0.55668
67	17	16.08	0.51793
68	17	14.66	0.62002
69	17	30.49	0.02305
70	17	19.83	0.28284

71	17	12.39	0.77597
72	17	15.20	0.58080
73	17	23.05	0.14748
74	17	12.23	0.78616
75	17	9.75	0.91382
76	17	19.49	0.30112
77	17	31.37	0.01798
78	17	9.48	0.92397
79	17	13.67	0.69010
80	17	15.75	0.54186
81	17	10.37	0.88756
82	17	16.29	0.50343
83	17	22.88	0.15336
84	17	16.64	0.47872
85	17	27.34	0.05329
86	17	22.41	0.16956
87	17	15.42	0.56508
88	17	18.27	0.37175
89	17	11.47	0.83090
90	17	14.34	0.64313
91	17	18.16	0.37895
92	17	19.75	0.28713
93	17	18.07	0.38459
94	17	9.66	0.91738
95	17	10.10	0.89926
96	17	13.89	0.67454
97	17	10.79	0.86723
98	17	27.84	0.04681
99	17	28.44	0.04001
100	17	22.15	0.17886
Combined P-value for all tests (Using KS method)			0.77155

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	18.19	0.37679
2	17	14.37	0.64049
3	17	7.45	0.97688
4	17	19.66	0.29200
5	17	19.41	0.30562
6	17	20.63	0.24319
7	17	16.48	0.48987
8	17	11.47	0.83122
9	17	18.04	0.38609
10	17	16.12	0.51509
11	17	23.61	0.13037
12	17	14.94	0.60005

13	17	21.26	0.21487
14	17	18.26	0.37238
15	17	20.68	0.24084
16	17	9.90	0.90794
17	17	8.90	0.94337
18	17	13.08	0.73056
19	17	29.06	0.03394
20	17	18.44	0.36142
21	17	23.76	0.12613
22	17	18.50	0.35810
23	17	18.58	0.35328
24	17	12.90	0.74312
25	17	20.97	0.22741
26	17	19.74	0.28778
27	17	18.09	0.38288
28	17	22.63	0.16170
29	17	23.31	0.13942
30	17	19.76	0.28674
31	17	13.76	0.68393
32	17	15.35	0.57003
33	17	8.32	0.95922
34	17	26.72	0.06231
35	17	13.34	0.71321
36	17	18.41	0.36327
37	17	12.00	0.80039
38	17	12.59	0.76318
39	17	14.53	0.62944
40	17	27.03	0.05767
41	17	9.12	0.93655
42	17	12.95	0.73925
43	17	22.51	0.16606
44	17	8.06	0.96529
45	17	16.74	0.47222
46	17	10.87	0.86300
47	17	31.19	0.01896
48	17	18.85	0.33744
49	17	13.20	0.72263
50	17	23.89	0.12258
51	17	8.58	0.95252
52	17	16.09	0.51717
53	17	12.75	0.75267
54	17	17.12	0.44641
55	17	10.54	0.87941
56	17	24.68	0.10222
57	17	11.09	0.85164
58	17	17.09	0.44812
59	17	16.12	0.51528
60	17	18.48	0.35889
61	17	17.34	0.43142

62	17	10.94	0.85992
63	17	16.42	0.49423
64	17	17.31	0.43363
65	17	7.46	0.97677
66	17	25.56	0.08282
67	17	22.22	0.17638
68	17	12.02	0.79912
69	17	14.38	0.63983
70	17	26.34	0.06848
71	17	29.87	0.02730
72	17	7.90	0.96869
73	17	14.16	0.65597
74	17	6.49	0.98927
75	17	37.22	0.00314
76	17	10.33	0.88905
77	17	23.48	0.13432
78	17	15.50	0.55970
79	17	17.66	0.41059
80	17	17.30	0.43391
81	17	17.31	0.43335
82	17	10.91	0.86133
83	17	13.97	0.66911
84	17	26.62	0.06391
85	17	13.49	0.70269
86	17	16.06	0.51929
87	17	8.66	0.95022
88	17	21.56	0.20215
89	17	15.04	0.59284
90	17	15.59	0.55287
91	17	17.95	0.39222
92	17	9.43	0.92570
93	17	7.77	0.97126
94	17	13.00	0.73620
95	17	14.51	0.63084
96	17	23.48	0.13430
97	17	12.70	0.75598
98	17	15.54	0.55697
99	17	26.49	0.06594
100	17	18.10	0.38229
Combined P-value for all tests (Using KS method)			0.93273

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	40.11	0.84019
2	50	46.11	0.63015
3	50	39.17	0.86530

4	50	43.16	0.74216
5	50	66.36	0.06052
6	50	35.27	0.94303
7	50	45.06	0.67143
8	50	42.69	0.75891
9	50	47.66	0.56781
10	50	31.64	0.98012
11	50	46.00	0.63469
12	50	46.18	0.62756
13	50	41.96	0.78342
14	50	49.66	0.48715
15	50	47.43	0.57692
16	50	45.04	0.67243
17	50	43.93	0.71416
18	50	44.02	0.71080
19	50	45.46	0.65589
20	50	68.38	0.04304
21	50	49.15	0.50732
22	50	57.67	0.21266
23	50	44.00	0.71176
24	50	39.77	0.84961
25	50	91.68	0.00030
26	50	40.89	0.81730
27	50	41.20	0.80776
28	50	62.25	0.11463
29	50	58.34	0.19559
30	50	54.20	0.31726
31	50	41.72	0.79128
32	50	49.95	0.47547
33	50	50.70	0.44595
34	50	51.02	0.43317
35	50	65.13	0.07384
36	50	56.82	0.23604
37	50	60.39	0.14910
38	50	47.79	0.56235
39	50	46.63	0.60944
40	50	52.13	0.39124
41	50	50.62	0.44909
42	50	47.06	0.59192
43	50	53.41	0.34478
44	50	39.92	0.84543
45	50	61.53	0.12703
46	50	53.17	0.35325
47	50	58.25	0.19785
48	50	43.92	0.71462
49	50	55.23	0.28365
50	50	41.32	0.80411
51	50	56.06	0.25797
52	50	44.14	0.70647

53	50	58.56	0.19008
54	50	43.41	0.73348
55	50	36.92	0.91546
56	50	55.36	0.27972
57	50	43.19	0.74115
58	50	72.41	0.02078
59	50	55.22	0.28399
60	50	47.64	0.56846
61	50	57.90	0.20663
62	50	45.03	0.67271
63	50	57.38	0.22059
64	50	49.72	0.48443
65	50	32.10	0.97698
66	50	52.01	0.39573
67	50	56.31	0.25055
68	50	56.41	0.24765
69	50	46.71	0.60611
70	50	48.23	0.54461
71	50	52.18	0.38917
72	50	49.14	0.50804
73	50	41.64	0.79384
74	50	54.52	0.30669
75	50	42.13	0.77796
76	50	58.86	0.18285
77	50	59.16	0.17600
78	50	63.46	0.09565
79	50	57.35	0.22121
80	50	49.28	0.50215
81	50	40.62	0.82545
82	50	41.90	0.78547
83	50	37.03	0.91339
84	50	63.11	0.10085
85	50	50.42	0.45672
86	50	52.05	0.39403
87	50	46.07	0.63162
88	50	50.77	0.44290
89	50	61.10	0.13505
90	50	55.80	0.26591
91	50	40.36	0.83316
92	50	79.29	0.00522
93	50	52.36	0.38258
94	50	45.67	0.64749
95	50	44.33	0.69953
96	50	46.84	0.60078
97	50	55.54	0.27383
98	50	40.88	0.81778
99	50	65.96	0.06458
100	50	40.11	0.84006
Combined P-value for all tests			0.52085

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	6.96	0.86044
2	12	6.45	0.89166
3	12	11.95	0.45008
4	12	8.83	0.71746
5	12	14.10	0.29455
6	12	25.58	0.01230
7	12	13.80	0.31385
8	12	10.36	0.58428
9	12	4.21	0.97939
10	12	8.53	0.74238
11	12	9.58	0.65285
12	12	5.63	0.93371
13	12	12.76	0.38667
14	12	18.91	0.09081
15	12	7.69	0.80896
16	12	8.48	0.74619
17	12	9.53	0.65748
18	12	8.79	0.72106
19	12	12.97	0.37098
20	12	5.10	0.95466
21	12	5.65	0.93289
22	12	10.33	0.58742
23	12	18.98	0.08910
24	12	11.79	0.46249
25	12	3.72	0.98795
26	12	26.20	0.01007
27	12	16.70	0.16143
28	12	11.04	0.52562
29	12	6.19	0.90617
30	12	10.30	0.58984
31	12	9.65	0.64704
32	12	24.99	0.01485
33	12	29.65	0.00315
34	12	8.24	0.76612
35	12	9.82	0.63174
36	12	17.09	0.14635
37	12	18.77	0.09432

38	12	11.00	0.52856
39	12	9.87	0.62727
40	12	11.67	0.47290
41	12	20.81	0.05325
42	12	14.64	0.26154
43	12	9.97	0.61883
44	12	7.13	0.84879
45	12	9.19	0.68641
46	12	14.19	0.28899
47	12	11.83	0.45943
48	12	11.26	0.50665
49	12	11.96	0.44857
50	12	12.37	0.41630
51	12	17.58	0.12898
52	12	10.29	0.59065
53	12	13.81	0.31321
54	12	6.56	0.88553
55	12	9.62	0.64940
56	12	5.60	0.93492
57	12	17.24	0.14068
58	12	17.62	0.12758
59	12	7.63	0.81311
60	12	16.56	0.16705
61	12	10.22	0.59671
62	12	18.83	0.09272
63	12	29.24	0.00363
64	12	7.25	0.84086
65	12	10.83	0.54345
66	12	8.28	0.76327
67	12	19.95	0.06810
68	12	6.44	0.89226
69	12	12.31	0.42108
70	12	8.53	0.74229
71	12	9.86	0.62818
72	12	8.19	0.76983
73	12	20.67	0.05549
74	12	7.30	0.83723
75	12	7.48	0.82444
76	12	5.58	0.93589
77	12	19.55	0.07604
78	12	7.71	0.80717
79	12	7.28	0.83828
80	12	18.67	0.09692
81	12	13.60	0.32726
82	12	11.42	0.49321
83	12	10.15	0.60291
84	12	17.64	0.12693
85	12	18.65	0.09743
86	12	5.66	0.93242

87	12	11.12	0.51853
88	12	15.15	0.23309
89	12	10.87	0.54038
90	12	14.82	0.25133
91	12	14.19	0.28895
92	12	7.77	0.80282
93	12	10.69	0.55550
94	12	5.23	0.94994
95	12	7.18	0.84582
96	12	15.85	0.19808
97	12	7.00	0.85766
98	12	3.26	0.99340
99	12	5.46	0.94073
100	12	14.58	0.26535
Combined P-value for all tests (Using KS method)			0.45944

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	9.66	0.64592
2	12	9.28	0.67875
3	12	8.03	0.78292
4	12	17.07	0.14703
5	12	14.65	0.26122
6	12	7.78	0.80194
7	12	20.33	0.06116
8	12	12.39	0.41491
9	12	13.54	0.33106
10	12	17.25	0.14027
11	12	19.32	0.08105
12	12	7.95	0.78934
13	12	12.97	0.37159
14	12	12.66	0.39439
15	12	12.05	0.44195
16	12	15.69	0.20566
17	12	17.07	0.14681
18	12	13.90	0.30714
19	12	22.66	0.03074
20	12	10.88	0.53893
21	12	13.12	0.36015
22	12	6.55	0.88615
23	12	18.47	0.10224
24	12	6.35	0.89755
25	12	14.68	0.25959
26	12	3.93	0.98472
27	12	16.44	0.17199
28	12	3.76	0.98746
29	12	23.79	0.02174
30	12	14.24	0.28577
31	12	6.87	0.86616
32	12	16.03	0.18997

33	12	12.23	0.42729
34	12	22.48	0.03245
35	12	11.40	0.49492
36	12	15.20	0.23054
37	12	12.83	0.38146
38	12	8.99	0.70363
39	12	21.63	0.04189
40	12	7.71	0.80737
41	12	11.49	0.48777
42	12	8.98	0.70503
43	12	5.64	0.93311
44	12	16.24	0.18047
45	12	5.65	0.93266
46	12	13.17	0.35716
47	12	14.01	0.29991
48	12	12.91	0.37551
49	12	11.96	0.44923
50	12	18.05	0.11423
51	12	11.04	0.52590
52	12	18.89	0.09131
53	12	12.49	0.40691
54	12	11.09	0.52141
55	12	14.34	0.27982
56	12	6.56	0.88505
57	12	13.20	0.35474
58	12	4.95	0.95957
59	12	2.97	0.99573
60	12	12.33	0.41931
61	12	12.24	0.42688
62	12	3.96	0.98418
63	12	7.56	0.81821
64	12	7.21	0.84332
65	12	17.64	0.12700
66	12	10.15	0.60311
67	12	9.30	0.67752
68	12	9.40	0.66813
69	12	9.08	0.69623
70	12	14.37	0.27751
71	12	3.42	0.99178
72	12	8.97	0.70526
73	12	11.57	0.48106
74	12	7.81	0.79962
75	12	8.89	0.71203
76	12	12.13	0.43543
77	12	9.17	0.68820
78	12	20.57	0.05698
79	12	21.42	0.04453
80	12	7.32	0.83592
81	12	19.81	0.07068
82	12	13.51	0.33287
83	12	3.95	0.98425
84	12	10.04	0.61289
85	12	9.23	0.68289
86	12	10.60	0.56351
87	12	13.70	0.32035
88	12	8.78	0.72141

89	12	18.93	0.09028
90	12	11.39	0.49616
91	12	14.95	0.24432
92	12	18.67	0.09693
93	12	6.84	0.86819
94	12	15.55	0.21280
95	12	14.98	0.24266
96	12	10.48	0.57349
97	12	9.94	0.62099
98	12	17.18	0.14283
99	12	10.84	0.54241
100	12	10.17	0.60093
Combined P-value for all tests (Using KS method)			0.84293

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)	0.77155	1.00000
Opening Score (Dealer)	0.93273	1.00000
Dealer's Final Score	0.52085	1.00000
Player Cards Rank	0.45944	1.00000
Dealer Cards Rank	0.84293	1.00000
Combined P-Value using Holm's Method		1.00000

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
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iTech Labs Australia
Date: 14 March 2024

Signed:



Alvin Rizaldi
Chief Executive Officer
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Date: 14 March 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.