



## Blackjack Cards Analysis – August 2024

### The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **August 01, 2024, to August 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	25.37	0.08673
2	17	17.28	0.43560
3	17	10.31	0.89002
4	17	11.30	0.84029
5	17	21.85	0.19067
6	17	37.43	0.00294
7	17	11.54	0.82736
8	17	19.39	0.30686
9	17	20.36	0.25623
10	17	11.79	0.81295
11	17	15.47	0.56188
12	17	12.11	0.79342
13	17	17.41	0.42675
14	17	8.96	0.94162
15	17	14.92	0.60142
16	17	19.64	0.29306
17	17	13.77	0.68321
18	17	22.36	0.17112
19	17	26.81	0.06093
20	17	13.98	0.66826
21	17	25.37	0.08679

22	17	16.30	0.50237
23	17	13.19	0.72364
24	17	19.00	0.32846
25	17	16.39	0.49644
26	17	18.55	0.35481
27	17	9.64	0.91807
28	17	29.98	0.02647
29	17	23.16	0.14410
30	17	22.74	0.15803
31	17	25.29	0.08838
32	17	13.12	0.72805
33	17	15.34	0.57086
34	17	18.67	0.34775
35	17	26.31	0.06906
36	17	21.70	0.19644
37	17	23.44	0.13537
38	17	17.75	0.40463
39	17	21.52	0.20382
40	17	15.91	0.53041
41	17	15.21	0.58070
42	17	10.74	0.86966
43	17	17.09	0.44849
44	17	24.21	0.11389
45	17	9.00	0.94020
46	17	14.69	0.61775
47	17	9.90	0.90780
48	17	34.62	0.00698
49	17	8.12	0.96391
50	17	10.42	0.88511
51	17	10.82	0.86573
52	17	15.74	0.54249
53	17	17.49	0.42160
54	17	29.05	0.03409
55	17	13.64	0.69272
56	17	7.11	0.98204
57	17	16.42	0.49427
58	17	18.60	0.35179
59	17	11.81	0.81169
60	17	14.52	0.63000
61	17	18.21	0.37575
62	17	16.51	0.48802
63	17	17.52	0.41953
64	17	12.13	0.79221
65	17	17.80	0.40180
66	17	22.21	0.17688
67	17	23.90	0.12225
68	17	18.25	0.37324
69	17	14.54	0.62849
70	17	17.91	0.39449

71	17	17.03	0.45229
72	17	14.06	0.66278
73	17	23.76	0.12600
74	17	23.83	0.12418
75	17	11.46	0.83175
76	17	19.12	0.32166
77	17	21.82	0.19188
78	17	17.03	0.45237
79	17	12.17	0.79003
80	17	6.72	0.98689
81	17	14.73	0.61483
82	17	16.97	0.45665
83	17	19.18	0.31849
84	17	20.11	0.26874
85	17	10.54	0.87936
86	17	9.22	0.93297
87	17	7.45	0.97686
88	17	12.57	0.76476
89	17	16.95	0.45792
90	17	10.63	0.87530
91	17	18.74	0.34362
92	17	21.88	0.18943
93	17	25.72	0.07975
94	17	26.93	0.05909
95	17	9.76	0.91330
96	17	16.50	0.48853
97	17	21.68	0.19731
98	17	20.07	0.27042
99	17	12.25	0.78481
100	17	23.67	0.12869
Combined P-value for all tests (Using KS method)			0.73575

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	18.17	0.37800
2	17	25.12	0.09199
3	17	7.30	0.97933
4	17	15.43	0.56469
5	17	12.30	0.78183
6	17	9.30	0.93041
7	17	12.10	0.79392
8	17	15.93	0.52849
9	17	11.13	0.84999
10	17	9.08	0.93756
11	17	21.45	0.20660
12	17	15.76	0.54110

13	17	15.34	0.57081
14	17	19.03	0.32694
15	17	8.05	0.96552
16	17	24.27	0.11236
17	17	13.76	0.68383
18	17	22.15	0.17897
19	17	17.38	0.42873
20	17	14.46	0.63414
21	17	28.41	0.04038
22	17	21.21	0.21686
23	17	15.02	0.59390
24	17	24.22	0.11363
25	17	18.29	0.37069
26	17	14.53	0.62902
27	17	11.42	0.83410
28	17	14.25	0.64955
29	17	16.01	0.52278
30	17	12.78	0.75078
31	17	16.62	0.48062
32	17	14.88	0.60428
33	17	13.44	0.70624
34	17	25.81	0.07801
35	17	14.34	0.64291
36	17	17.68	0.40961
37	17	29.01	0.03439
38	17	20.92	0.22986
39	17	7.96	0.96749
40	17	9.99	0.90394
41	17	27.16	0.05580
42	17	17.27	0.43615
43	17	19.89	0.27969
44	17	16.59	0.48242
45	17	9.50	0.92319
46	17	13.69	0.68873
47	17	15.39	0.56764
48	17	14.13	0.65759
49	17	11.78	0.81324
50	17	32.31	0.01378
51	17	15.18	0.58274
52	17	8.00	0.96665
53	17	31.75	0.01617
54	17	22.16	0.17880
55	17	18.76	0.34249
56	17	16.87	0.46337
57	17	11.00	0.85666
58	17	31.02	0.01986
59	17	22.53	0.16507
60	17	17.99	0.38947
61	17	9.39	0.92734

62	17	38.75	0.00193
63	17	12.78	0.75085
64	17	16.25	0.50646
65	17	9.28	0.93112
66	17	21.65	0.19858
67	17	30.27	0.02443
68	17	24.55	0.10522
69	17	24.10	0.11679
70	17	10.49	0.88181
71	17	14.81	0.60896
72	17	12.94	0.74021
73	17	13.74	0.68570
74	17	9.96	0.90526
75	17	10.73	0.87029
76	17	11.55	0.82638
77	17	15.98	0.52538
78	17	12.79	0.75021
79	17	23.08	0.14661
80	17	8.61	0.95167
81	17	12.56	0.76514
82	17	18.98	0.32962
83	17	23.95	0.12072
84	17	19.91	0.27866
85	17	26.58	0.06452
86	17	15.82	0.53677
87	17	18.11	0.38202
88	17	16.60	0.48154
89	17	12.76	0.75181
90	17	3.90	0.99956
91	17	13.18	0.72382
92	17	10.94	0.85956
93	17	26.72	0.06228
94	17	12.93	0.74071
95	17	11.89	0.80685
96	17	13.21	0.72178
97	17	9.21	0.93351
98	17	8.01	0.96631
99	17	14.12	0.65872
100	17	15.45	0.56315
Combined P-value for all tests (Using KS method)			0.22833

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	82.16	0.00280
2	50	46.59	0.61103
3	50	40.43	0.83100

4	50	62.56	0.10942
5	50	58.10	0.20166
6	50	35.91	0.93314
7	50	63.86	0.08997
8	50	69.81	0.03351
9	50	63.12	0.10075
10	50	56.33	0.25011
11	50	31.21	0.98284
12	50	56.85	0.23528
13	50	38.88	0.87271
14	50	74.41	0.01416
15	50	59.19	0.17511
16	50	50.57	0.45101
17	50	41.16	0.80914
18	50	33.14	0.96822
19	50	39.46	0.85791
20	50	34.40	0.95469
21	50	54.96	0.29219
22	50	37.49	0.90424
23	50	51.36	0.42006
24	50	37.03	0.91343
25	50	52.46	0.37879
26	50	64.97	0.07576
27	50	48.59	0.53018
28	50	47.45	0.57618
29	50	45.31	0.66174
30	50	49.44	0.49581
31	50	37.14	0.91117
32	50	43.96	0.71316
33	50	41.98	0.78272
34	50	33.53	0.96440
35	50	51.99	0.39619
36	50	53.06	0.35709
37	50	38.72	0.87654
38	50	44.02	0.71087
39	50	51.84	0.40188
40	50	54.92	0.29361
41	50	46.60	0.61045
42	50	60.39	0.14914
43	50	48.97	0.51461
44	50	35.81	0.93488
45	50	41.88	0.78599
46	50	58.72	0.18625
47	50	44.88	0.67852
48	50	46.39	0.61908
49	50	39.19	0.86483
50	50	46.60	0.61051
51	50	49.51	0.49314
52	50	45.91	0.63808

53	50	36.37	0.92552
54	50	40.50	0.82893
55	50	43.86	0.71675
56	50	54.21	0.31717
57	50	34.84	0.94905
58	50	30.74	0.98541
59	50	63.26	0.09859
60	50	53.66	0.33598
61	50	63.17	0.09989
62	50	37.37	0.90667
63	50	50.99	0.43446
64	50	52.89	0.36304
65	50	34.47	0.95382
66	50	65.74	0.06691
67	50	79.92	0.00456
68	50	59.21	0.17462
69	50	55.04	0.28966
70	50	30.51	0.98653
71	50	70.02	0.03226
72	50	43.93	0.71414
73	50	75.82	0.01070
74	50	33.60	0.96370
75	50	32.31	0.97541
76	50	53.14	0.35421
77	50	45.03	0.67251
78	50	43.13	0.74328
79	50	60.25	0.15202
80	50	46.95	0.59645
81	50	42.78	0.75581
82	50	41.12	0.81020
83	50	44.42	0.69606
84	50	53.03	0.35828
85	50	41.55	0.79677
86	50	41.20	0.80797
87	50	42.71	0.75816
88	50	52.09	0.39273
89	50	42.76	0.75636
90	50	66.41	0.06001
91	50	59.92	0.15897
92	50	40.29	0.83489
93	50	32.96	0.96993
94	50	33.01	0.96948
95	50	54.19	0.31769
96	50	47.57	0.57163
97	50	73.59	0.01661
98	50	52.26	0.38628
99	50	44.38	0.69765
100	50	48.39	0.53821
Combined P-value for all tests			0.12589

*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	14.91	0.24636
2	12	19.21	0.08364
3	12	12.87	0.37854
4	12	12.36	0.41696
5	12	17.63	0.12734
6	12	20.88	0.05223
7	12	11.64	0.47498
8	12	9.99	0.61654
9	12	31.10	0.00190
10	12	12.81	0.38293
11	12	5.04	0.95676
12	12	10.90	0.53749
13	12	17.62	0.12786
14	12	16.50	0.16938
15	12	18.79	0.09372
16	12	8.78	0.72147
17	12	11.44	0.49201
18	12	12.83	0.38138
19	12	7.65	0.81202
20	12	6.38	0.89598
21	12	23.49	0.02387
22	12	6.56	0.88515
23	12	15.90	0.19604
24	12	13.11	0.36140
25	12	6.67	0.87875
26	12	8.99	0.70371
27	12	17.83	0.12110
28	12	13.72	0.31867
29	12	6.69	0.87759
30	12	7.08	0.85227
31	12	13.98	0.30205
32	12	26.11	0.01036
33	12	6.15	0.90834
34	12	8.05	0.78143
35	12	14.03	0.29901
36	12	13.48	0.33501
37	12	12.36	0.41716



38	12	9.52	0.65785
39	12	9.26	0.68082
40	12	9.89	0.62555
41	12	5.42	0.94236
42	12	8.83	0.71756
43	12	16.91	0.15299
44	12	12.91	0.37539
45	12	11.59	0.47907
46	12	13.69	0.32120
47	12	13.63	0.32498
48	12	10.38	0.58303
49	12	7.85	0.79645
50	12	20.43	0.05939
51	12	10.03	0.61359
52	12	12.27	0.42410
53	12	10.43	0.57865
54	12	12.22	0.42803
55	12	23.76	0.02195
56	12	5.36	0.94480
57	12	15.47	0.21651
58	12	9.48	0.66183
59	12	8.47	0.74734
60	12	4.99	0.95842
61	12	6.86	0.86652
62	12	6.13	0.90921
63	12	5.96	0.91823
64	12	5.15	0.95274
65	12	11.28	0.50545
66	12	4.88	0.96194
67	12	7.21	0.84329
68	12	11.42	0.49345
69	12	15.52	0.21425
70	12	13.47	0.33575
71	12	16.20	0.18228
72	12	16.63	0.16411
73	12	9.81	0.63306
74	12	8.63	0.73448
75	12	15.03	0.23978
76	12	15.57	0.21167
77	12	20.59	0.05664
78	12	12.55	0.40227
79	12	10.05	0.61159
80	12	9.99	0.61665
81	12	5.22	0.95015
82	12	18.58	0.09914
83	12	11.33	0.50075
84	12	6.27	0.90188
85	12	13.09	0.36226
86	12	16.94	0.15202

87	12	2.43	0.99840
88	12	18.97	0.08917
89	12	20.74	0.05426
90	12	21.99	0.03765
91	12	10.12	0.60552
92	12	11.34	0.50021
93	12	13.15	0.35813
94	12	10.59	0.56439
95	12	5.06	0.95611
96	12	13.15	0.35804
97	12	6.48	0.89008
98	12	15.94	0.19413
99	12	11.96	0.44865
100	12	15.87	0.19709
Combined P-value for all tests (Using KS method)			0.88545

*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	6.06	0.91305
2	12	19.00	0.08855
3	12	5.73	0.92895
4	12	14.00	0.30063
5	12	17.43	0.13421
6	12	5.67	0.93187
7	12	13.81	0.31329
8	12	9.08	0.69646
9	12	22.16	0.03580
10	12	13.19	0.35515
11	12	11.66	0.47352
12	12	9.73	0.63996
13	12	9.83	0.63102
14	12	8.74	0.72506
15	12	8.01	0.78402
16	12	9.73	0.64002
17	12	11.59	0.47937
18	12	20.41	0.05973
19	12	9.72	0.64025
20	12	5.04	0.95668
21	12	14.54	0.26755
22	12	13.27	0.34954
23	12	16.53	0.16829
24	12	15.77	0.20185
25	12	4.66	0.96836
26	12	11.82	0.46030
27	12	10.62	0.56173
28	12	10.49	0.57323
29	12	12.97	0.37120
30	12	9.13	0.69166
31	12	12.38	0.41545
32	12	16.80	0.15712

33	12	19.79	0.07121
34	12	12.88	0.37748
35	12	20.60	0.05650
36	12	14.72	0.25713
37	12	15.12	0.23498
38	12	13.35	0.34390
39	12	8.32	0.75942
40	12	16.61	0.16504
41	12	11.15	0.51642
42	12	20.27	0.06213
43	12	13.72	0.31876
44	12	6.96	0.86018
45	12	10.32	0.58830
46	12	23.91	0.02094
47	12	8.85	0.71563
48	12	17.51	0.13142
49	12	14.53	0.26803
50	12	16.48	0.17043
51	12	11.76	0.46555
52	12	19.59	0.07522
53	12	9.83	0.63072
54	12	26.35	0.00957
55	12	8.96	0.70658
56	12	10.49	0.57284
57	12	15.93	0.19424
58	12	5.21	0.95052
59	12	5.77	0.92711
60	12	11.70	0.47038
61	12	16.18	0.18335
62	12	12.92	0.37479
63	12	15.03	0.23991
64	12	10.17	0.60085
65	12	20.71	0.05482
66	12	9.45	0.66437
67	12	5.79	0.92619
68	12	17.77	0.12288
69	12	13.08	0.36345
70	12	7.55	0.81891
71	12	2.87	0.99641
72	12	8.13	0.77472
73	12	18.73	0.09525
74	12	11.06	0.52373
75	12	12.10	0.43753
76	12	12.72	0.38998
77	12	11.29	0.50385
78	12	7.26	0.84004
79	12	10.23	0.59596
80	12	4.99	0.95846
81	12	11.75	0.46586
82	12	22.90	0.02858
83	12	29.56	0.00325
84	12	17.95	0.11716
85	12	24.77	0.01593
86	12	4.99	0.95842
87	12	5.95	0.91839
88	12	7.95	0.78916

89	12	9.88	0.62605
90	12	17.32	0.13803
91	12	17.34	0.13734
92	12	9.05	0.69856
93	12	5.80	0.92566
94	12	5.68	0.93146
95	12	17.18	0.14308
96	12	5.33	0.94612
97	12	7.43	0.82824
98	12	6.74	0.87453
99	12	15.55	0.21270
100	12	8.33	0.75861
Combined P-value for all tests (Using KS method)			0.70329

*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)	0.73575	1.00000
Opening Score (Dealer)	0.22833	0.91333
Dealer's Final Score	0.12589	0.62944
Player Cards Rank	0.88545	1.00000
Dealer Cards Rank	0.70329	1.00000
Combined P-Value using Holm's Method		0.62944

*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.

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**Signed:**



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**Divya Bhargava**  
**Project Manager**  
**iTech Labs Australia**

Date: 16 September 2024

**Signed:**



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**Alvin Rizaldi**  
**Chief Executive Officer**  
**iTech Labs Australia**

Date: 16 September 2024

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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.