



## Blackjack Cards Analysis – October 2024

### The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **October 01, 2024, to October 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	23.41	0.13636
2	17	10.70	0.87150
3	17	16.06	0.51965
4	17	10.13	0.89802
5	17	10.97	0.85829
6	17	17.98	0.38997
7	17	19.99	0.27473
8	17	23.40	0.13673
9	17	20.69	0.24046
10	17	19.32	0.31069
11	17	16.69	0.47543
12	17	16.38	0.49717
13	17	18.48	0.35926
14	17	17.56	0.41716
15	17	9.74	0.91413
16	17	20.46	0.25124
17	17	10.36	0.88775
18	17	13.50	0.70202
19	17	15.71	0.54436
20	17	22.07	0.18185
21	17	14.18	0.65445

22	17	21.61	0.20008
23	17	12.65	0.75930
24	17	14.81	0.60950
25	17	15.52	0.55827
26	17	18.98	0.32989
27	17	13.57	0.69717
28	17	18.71	0.34520
29	17	10.56	0.87844
30	17	15.28	0.57567
31	17	15.85	0.53453
32	17	8.39	0.95752
33	17	15.58	0.55385
34	17	9.72	0.91477
35	17	22.29	0.17373
36	17	12.90	0.74317
37	17	30.58	0.02247
38	17	17.50	0.42101
39	17	18.27	0.37209
40	17	14.91	0.60232
41	17	15.25	0.57783
42	17	7.00	0.98357
43	17	9.66	0.91732
44	17	16.06	0.51925
45	17	24.90	0.09689
46	17	20.85	0.23315
47	17	15.04	0.59233
48	17	17.13	0.44541
49	17	18.91	0.33344
50	17	15.23	0.57897
51	17	20.33	0.25792
52	17	24.01	0.11910
53	17	32.58	0.01274
54	17	14.31	0.64494
55	17	10.43	0.88468
56	17	21.08	0.22267
57	17	18.54	0.35536
58	17	23.08	0.14676
59	17	15.25	0.57752
60	17	12.14	0.79185
61	17	15.89	0.53134
62	17	22.63	0.16165
63	17	11.21	0.84542
64	17	10.93	0.86036
65	17	11.43	0.83319
66	17	23.60	0.13086
67	17	26.64	0.06356
68	17	12.06	0.79644
69	17	10.89	0.86199
70	17	9.15	0.93541

71	17	14.00	0.66681
72	17	18.79	0.34052
73	17	21.11	0.22127
74	17	16.94	0.45876
75	17	14.55	0.62788
76	17	12.23	0.78620
77	17	12.23	0.78624
78	17	13.12	0.72812
79	17	10.17	0.89616
80	17	16.34	0.49973
81	17	14.42	0.63722
82	17	35.52	0.00531
83	17	14.36	0.64182
84	17	23.89	0.12247
85	17	16.55	0.48516
86	17	9.37	0.92786
87	17	7.59	0.97447
88	17	18.17	0.37795
89	17	17.08	0.44910
90	17	21.17	0.21890
91	17	14.11	0.65940
92	17	16.94	0.45817
93	17	14.89	0.60324
94	17	21.62	0.19985
95	17	8.39	0.95736
96	17	18.51	0.35756
97	17	14.88	0.60401
98	17	9.09	0.93742
99	17	11.48	0.83064
100	17	17.20	0.44086
Combined P-value for all tests (Using KS method)			0.52896

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	18.76	0.34265
2	17	18.73	0.34454
3	17	17.96	0.39158
4	17	13.56	0.69821
5	17	20.34	0.25701
6	17	10.84	0.86478
7	17	13.62	0.69350
8	17	18.22	0.37484
9	17	17.04	0.45165
10	17	8.90	0.94321
11	17	13.24	0.71977
12	17	18.04	0.38658

13	17	8.12	0.96380
14	17	25.03	0.09411
15	17	11.63	0.82185
16	17	13.18	0.72397
17	17	12.71	0.75515
18	17	19.11	0.32250
19	17	15.57	0.55480
20	17	21.55	0.20276
21	17	21.20	0.21764
22	17	20.03	0.27269
23	17	22.74	0.15799
24	17	19.92	0.27809
25	17	19.73	0.28808
26	17	21.87	0.18982
27	17	24.85	0.09811
28	17	13.92	0.67302
29	17	15.67	0.54720
30	17	16.18	0.51138
31	17	7.79	0.97078
32	17	14.69	0.61758
33	17	13.03	0.73442
34	17	13.81	0.68020
35	17	14.10	0.66027
36	17	17.24	0.43837
37	17	13.95	0.67069
38	17	13.64	0.69233
39	17	14.92	0.60097
40	17	17.11	0.44677
41	17	12.72	0.75450
42	17	10.99	0.85706
43	17	17.03	0.45235
44	17	13.06	0.73187
45	17	21.25	0.21516
46	17	11.48	0.83049
47	17	14.17	0.65536
48	17	15.74	0.54257
49	17	37.79	0.00263
50	17	17.39	0.42827
51	17	17.62	0.41341
52	17	14.58	0.62553
53	17	13.15	0.72579
54	17	21.08	0.22292
55	17	28.19	0.04281
56	17	33.71	0.00915
57	17	15.72	0.54388
58	17	23.74	0.12669
59	17	15.02	0.59380
60	17	21.27	0.21459
61	17	14.17	0.65490

62	17	11.99	0.80055
63	17	16.83	0.46603
64	17	12.81	0.74868
65	17	11.50	0.82947
66	17	19.41	0.30558
67	17	17.08	0.44900
68	17	19.26	0.31393
69	17	10.99	0.85687
70	17	12.51	0.76846
71	17	11.07	0.85272
72	17	17.27	0.43617
73	17	6.21	0.99170
74	17	21.74	0.19493
75	17	16.87	0.46334
76	17	19.92	0.27824
77	17	16.80	0.46831
78	17	33.69	0.00920
79	17	16.41	0.49501
80	17	12.15	0.79095
81	17	13.94	0.67099
82	17	27.60	0.04982
83	17	15.88	0.53257
84	17	19.97	0.27555
85	17	20.14	0.26727
86	17	22.50	0.16616
87	17	16.14	0.51422
88	17	15.25	0.57722
89	17	16.34	0.49959
90	17	13.25	0.71933
91	17	12.07	0.79563
92	17	17.72	0.40692
93	17	10.54	0.87928
94	17	31.99	0.01507
95	17	28.31	0.04148
96	17	10.31	0.89005
97	17	26.98	0.05841
98	17	25.96	0.07520
99	17	21.15	0.21978
100	17	12.12	0.79283
Combined P-value for all tests (Using KS method)			0.77520

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	42.30	0.77211
2	50	51.84	0.40213
3	50	38.77	0.87531

4	50	52.65	0.37191
5	50	38.91	0.87188
6	50	53.63	0.33691
7	50	62.39	0.11227
8	50	51.18	0.42699
9	50	42.66	0.75998
10	50	35.76	0.93562
11	50	53.24	0.35067
12	50	44.97	0.67494
13	50	49.66	0.48688
14	50	52.04	0.39435
15	50	51.26	0.42413
16	50	64.31	0.08403
17	50	50.59	0.44996
18	50	39.03	0.86898
19	50	46.10	0.63068
20	50	39.43	0.85871
21	50	42.11	0.77863
22	50	41.94	0.78426
23	50	52.19	0.38884
24	50	53.02	0.35851
25	50	45.86	0.64029
26	50	52.86	0.36422
27	50	45.55	0.65246
28	50	43.11	0.74403
29	50	38.21	0.88853
30	50	40.34	0.83371
31	50	64.81	0.07770
32	50	51.24	0.42492
33	50	49.99	0.47360
34	50	47.42	0.57763
35	50	65.00	0.07537
36	50	38.43	0.88341
37	50	57.06	0.22919
38	50	41.11	0.81066
39	50	46.47	0.61598
40	50	49.66	0.48684
41	50	48.95	0.51568
42	50	50.69	0.44622
43	50	41.41	0.80119
44	50	43.31	0.73706
45	50	63.12	0.10072
46	50	37.42	0.90553
47	50	47.92	0.55744
48	50	44.10	0.70782
49	50	35.34	0.94205
50	50	53.99	0.32438
51	50	51.72	0.40652
52	50	68.00	0.04595

53	50	35.16	0.94463
54	50	63.08	0.10125
55	50	53.75	0.33267
56	50	47.65	0.56820
57	50	42.96	0.74936
58	50	53.20	0.35202
59	50	56.72	0.23894
60	50	61.83	0.12181
61	50	49.52	0.49241
62	50	44.32	0.69990
63	50	39.67	0.85221
64	50	41.99	0.78255
65	50	47.56	0.57178
66	50	43.88	0.71600
67	50	81.55	0.00320
68	50	48.06	0.55155
69	50	63.61	0.09351
70	50	47.64	0.56861
71	50	80.76	0.00380
72	50	50.62	0.44880
73	50	48.09	0.55028
74	50	63.90	0.08950
75	50	64.80	0.07777
76	50	38.47	0.88252
77	50	30.41	0.98701
78	50	60.85	0.13987
79	50	59.34	0.17173
80	50	45.88	0.63941
81	50	44.01	0.71139
82	50	45.67	0.64765
83	50	45.36	0.65981
84	50	37.70	0.89966
85	50	62.95	0.10324
86	50	49.69	0.48559
87	50	37.13	0.91142
88	50	69.66	0.03439
89	50	55.68	0.26959
90	50	46.38	0.61949
91	50	46.48	0.61545
92	50	50.24	0.46386
93	50	59.28	0.17324
94	50	39.10	0.86707
95	50	51.99	0.39636
96	50	55.84	0.26468
97	50	60.91	0.13871
98	50	52.80	0.36648
99	50	57.31	0.22237
100	50	40.93	0.81604
Combined P-value for all tests			0.45795

*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	8.47	0.74718
2	12	13.25	0.35129
3	12	14.42	0.27498
4	12	8.65	0.73216
5	12	9.81	0.63306
6	12	15.17	0.23231
7	12	15.24	0.22866
8	12	25.92	0.01100
9	12	10.75	0.55030
10	12	14.14	0.29173
11	12	8.96	0.70669
12	12	18.73	0.09514
13	12	4.50	0.97251
14	12	8.37	0.75585
15	12	8.14	0.77406
16	12	13.13	0.35981
17	12	13.40	0.34073
18	12	23.30	0.02528
19	12	9.75	0.63822
20	12	25.08	0.01446
21	12	10.78	0.54821
22	12	10.31	0.58919
23	12	25.82	0.01140
24	12	15.04	0.23950
25	12	9.54	0.65652
26	12	15.57	0.21182
27	12	12.94	0.37326
28	12	9.93	0.62221
29	12	16.35	0.17572
30	12	15.90	0.19578
31	12	5.71	0.93003
32	12	8.84	0.71611
33	12	11.55	0.48276
34	12	16.45	0.17131
35	12	6.53	0.88725
36	12	13.87	0.30888
37	12	8.02	0.78367



38	12	17.22	0.14146
39	12	11.20	0.51190
40	12	13.40	0.34060
41	12	9.28	0.67852
42	12	14.24	0.28543
43	12	18.17	0.11064
44	12	7.21	0.84359
45	12	8.04	0.78233
46	12	10.92	0.53580
47	12	16.96	0.15098
48	12	10.67	0.55772
49	12	11.50	0.48682
50	12	11.77	0.46451
51	12	7.00	0.85793
52	12	22.28	0.03448
53	12	13.99	0.30144
54	12	13.47	0.33579
55	12	22.38	0.03349
56	12	25.41	0.01299
57	12	7.94	0.78999
58	12	16.25	0.17992
59	12	13.15	0.35845
60	12	4.34	0.97643
61	12	11.97	0.44845
62	12	17.95	0.11729
63	12	18.96	0.08954
64	12	11.09	0.52113
65	12	8.73	0.72568
66	12	16.56	0.16676
67	12	7.63	0.81324
68	12	3.60	0.98963
69	12	18.80	0.09352
70	12	4.10	0.98164
71	12	9.89	0.62549
72	12	16.22	0.18156
73	12	5.01	0.95778
74	12	15.79	0.20098
75	12	3.95	0.98439
76	12	11.90	0.45336
77	12	14.57	0.26576
78	12	3.35	0.99257
79	12	11.48	0.48788
80	12	14.67	0.26008
81	12	15.98	0.19228
82	12	10.92	0.53547
83	12	13.53	0.33172
84	12	7.01	0.85710
85	12	13.24	0.35151
86	12	15.49	0.21564

87	12	10.54	0.56859
88	12	12.13	0.43498
89	12	5.06	0.95602
90	12	10.72	0.55272
91	12	10.64	0.55997
92	12	11.38	0.49661
93	12	6.10	0.91095
94	12	16.86	0.15509
95	12	9.08	0.69600
96	12	11.50	0.48640
97	12	10.58	0.56546
98	12	7.72	0.80636
99	12	8.95	0.70685
100	12	13.21	0.35398
Combined P-value for all tests (Using KS method)			0.67189

*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	15.37	0.22161
2	12	13.22	0.35344
3	12	7.49	0.82378
4	12	16.52	0.16848
5	12	15.21	0.22997
6	12	6.24	0.90335
7	12	13.51	0.33296
8	12	13.27	0.34968
9	12	14.44	0.27342
10	12	5.00	0.95806
11	12	10.12	0.60536
12	12	13.57	0.32889
13	12	13.74	0.31766
14	12	8.82	0.71832
15	12	4.23	0.97884
16	12	9.59	0.65213
17	12	8.87	0.71364
18	12	12.12	0.43582
19	12	15.69	0.20579
20	12	15.04	0.23901
21	12	12.43	0.41182
22	12	7.10	0.85109
23	12	10.82	0.54472
24	12	7.85	0.79691
25	12	5.82	0.92496
26	12	15.27	0.22686
27	12	18.04	0.11433
28	12	22.15	0.03583
29	12	4.04	0.98265
30	12	14.37	0.27756
31	12	8.78	0.72194
32	12	14.06	0.29682

33	12	29.58	0.00323
34	12	10.08	0.60930
35	12	6.68	0.87772
36	12	15.83	0.19901
37	12	10.39	0.58163
38	12	1.89	0.99956
39	12	5.94	0.91898
40	12	12.36	0.41737
41	12	10.09	0.60827
42	12	17.56	0.12961
43	12	10.71	0.55389
44	12	12.30	0.42228
45	12	11.53	0.48439
46	12	10.80	0.54646
47	12	8.62	0.73489
48	12	15.31	0.22503
49	12	12.08	0.43903
50	12	14.34	0.27980
51	12	17.27	0.13983
52	12	9.84	0.63034
53	12	12.98	0.37053
54	12	12.59	0.39957
55	12	7.66	0.81079
56	12	5.24	0.94934
57	12	17.21	0.14178
58	12	12.04	0.44223
59	12	2.89	0.99628
60	12	14.95	0.24422
61	12	17.63	0.12742
62	12	13.77	0.31595
63	12	17.69	0.12553
64	12	13.24	0.35187
65	12	11.83	0.45902
66	12	21.55	0.04288
67	12	18.96	0.08940
68	12	20.97	0.05082
69	12	7.97	0.78763
70	12	10.78	0.54788
71	12	17.98	0.11630
72	12	9.47	0.66211
73	12	25.51	0.01258
74	12	14.40	0.27578
75	12	6.91	0.86341
76	12	9.42	0.66630
77	12	14.31	0.28135
78	12	25.68	0.01192
79	12	15.67	0.20684
80	12	14.91	0.24619
81	12	14.79	0.25297
82	12	9.59	0.65204
83	12	5.83	0.92425
84	12	10.37	0.58380
85	12	11.34	0.49995
86	12	7.72	0.80652
87	12	15.19	0.23100
88	12	12.96	0.37224

89	12	8.71	0.72770
90	12	12.57	0.40115
91	12	7.49	0.82376
92	12	12.03	0.44361
93	12	10.68	0.55629
94	12	11.81	0.46140
95	12	17.87	0.11955
96	12	14.33	0.27984
97	12	8.48	0.74687
98	12	9.88	0.62627
99	12	14.51	0.26938
100	12	7.54	0.82026
Combined P-value for all tests (Using KS method)			0.39603

*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)	0.52896	1.00000
Opening Score (Dealer)	0.77520	1.00000
Dealer's Final Score	0.45795	1.00000
Player Cards Rank	0.67189	1.00000
Dealer Cards Rank	0.39603	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.

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**Signed:**



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

Date: 15 November 2024

**Signed:**



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

Date: 15 November 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.

