



Blackjack Cards Analysis – November 2024

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **November 01, 2024, to November 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	24.46	0.10751
2	17	9.00	0.94032
3	17	13.13	0.72751
4	17	12.47	0.77120
5	17	23.87	0.12303
6	17	13.58	0.69645
7	17	11.81	0.81175
8	17	15.11	0.58721
9	17	6.53	0.98882
10	17	9.83	0.91048
11	17	21.35	0.21091
12	17	13.31	0.71531
13	17	13.71	0.68728
14	17	16.48	0.49001
15	17	28.34	0.04113
16	17	12.03	0.79827
17	17	18.66	0.34848
18	17	12.18	0.78909
19	17	14.07	0.66203
20	17	32.71	0.01226
21	17	10.04	0.90176

22	17	21.42	0.20791
23	17	21.78	0.19345
24	17	22.90	0.15259
25	17	12.58	0.76385
26	17	25.14	0.09151
27	17	18.10	0.38246
28	17	19.14	0.32077
29	17	21.58	0.20160
30	17	23.95	0.12069
31	17	14.87	0.60507
32	17	21.15	0.21965
33	17	24.45	0.10781
34	17	13.27	0.71765
35	17	8.93	0.94252
36	17	17.01	0.45362
37	17	25.02	0.09429
38	17	12.43	0.77343
39	17	7.43	0.97723
40	17	19.18	0.31817
41	17	16.53	0.48642
42	17	18.87	0.33601
43	17	15.73	0.54272
44	17	11.24	0.84364
45	17	11.54	0.82711
46	17	26.27	0.06966
47	17	17.31	0.43335
48	17	13.20	0.72246
49	17	9.71	0.91516
50	17	12.95	0.73944
51	17	17.09	0.44833
52	17	12.12	0.79282
53	17	18.47	0.35976
54	17	24.84	0.09833
55	17	20.12	0.26835
56	17	16.42	0.49394
57	17	23.77	0.12578
58	17	17.03	0.45208
59	17	21.81	0.19210
60	17	19.06	0.32484
61	17	9.02	0.93974
62	17	24.61	0.10382
63	17	20.93	0.22960
64	17	22.81	0.15568
65	17	18.14	0.38007
66	17	9.38	0.92764
67	17	19.92	0.27845
68	17	24.16	0.11511
69	17	12.58	0.76413
70	17	22.65	0.16095

71	17	41.23	0.00087
72	17	18.06	0.38518
73	17	16.68	0.47597
74	17	9.93	0.90665
75	17	16.72	0.47359
76	17	18.69	0.34663
77	17	12.27	0.78375
78	17	14.51	0.63093
79	17	13.87	0.67628
80	17	19.39	0.30662
81	17	13.65	0.69161
82	17	17.37	0.42991
83	17	14.92	0.60108
84	17	21.08	0.22287
85	17	27.36	0.05294
86	17	27.41	0.05237
87	17	18.28	0.37108
88	17	24.84	0.09839
89	17	28.48	0.03960
90	17	10.30	0.89043
91	17	20.66	0.24186
92	17	22.63	0.16186
93	17	21.61	0.20032
94	17	10.59	0.87710
95	17	18.24	0.37411
96	17	9.29	0.93069
97	17	13.83	0.67928
98	17	32.73	0.01220
99	17	19.15	0.31998
100	17	17.37	0.42989
Combined P-value for all tests (Using KS method)			0.29987

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	9.19	0.93424
2	17	9.91	0.90716
3	17	20.15	0.26672
4	17	19.31	0.31130
5	17	18.11	0.38170
6	17	26.02	0.07401
7	17	16.93	0.45913
8	17	19.81	0.28415
9	17	12.11	0.79371
10	17	13.09	0.72981
11	17	27.07	0.05702
12	17	24.02	0.11879

13	17	26.48	0.06611
14	17	10.76	0.86888
15	17	19.32	0.31046
16	17	15.46	0.56260
17	17	23.75	0.12633
18	17	17.19	0.44175
19	17	22.12	0.18019
20	17	23.02	0.14848
21	17	20.26	0.26095
22	17	23.54	0.13243
23	17	12.00	0.80011
24	17	12.44	0.77273
25	17	15.63	0.54984
26	17	10.37	0.88746
27	17	13.40	0.70907
28	17	15.93	0.52891
29	17	35.89	0.00474
30	17	11.18	0.84714
31	17	17.93	0.39301
32	17	22.11	0.18039
33	17	17.08	0.44910
34	17	8.46	0.95562
35	17	9.73	0.91450
36	17	17.91	0.39481
37	17	15.36	0.56951
38	17	19.63	0.29355
39	17	22.10	0.18105
40	17	10.94	0.85959
41	17	14.94	0.59991
42	17	13.64	0.69216
43	17	17.55	0.41771
44	17	15.45	0.56291
45	17	8.37	0.95808
46	17	15.65	0.54854
47	17	11.92	0.80489
48	17	29.17	0.03302
49	17	12.39	0.77606
50	17	14.13	0.65771
51	17	13.38	0.71047
52	17	8.05	0.96538
53	17	16.24	0.50692
54	17	10.73	0.87012
55	17	10.61	0.87628
56	17	9.17	0.93463
57	17	14.18	0.65417
58	17	17.03	0.45204
59	17	11.88	0.80722
60	17	12.09	0.79443
61	17	15.75	0.54175

62	17	21.64	0.19903
63	17	27.86	0.04661
64	17	19.46	0.30274
65	17	10.07	0.90060
66	17	14.75	0.61353
67	17	19.18	0.31857
68	17	12.83	0.74776
69	17	23.67	0.12882
70	17	17.93	0.39311
71	17	25.49	0.08436
72	17	17.82	0.40036
73	17	20.53	0.24807
74	17	6.94	0.98432
75	17	13.96	0.66998
76	17	22.97	0.15034
77	17	18.22	0.37479
78	17	9.55	0.92133
79	17	10.83	0.86550
80	17	16.72	0.47335
81	17	24.65	0.10273
82	17	11.34	0.83852
83	17	14.62	0.62250
84	17	29.00	0.03451
85	17	15.47	0.56155
86	17	29.53	0.02993
87	17	6.59	0.98824
88	17	11.51	0.82905
89	17	18.42	0.36259
90	17	22.03	0.18353
91	17	23.42	0.13596
92	17	22.45	0.16808
93	17	7.96	0.96732
94	17	15.78	0.53955
95	17	18.75	0.34294
96	17	14.99	0.59652
97	17	23.50	0.13361
98	17	12.27	0.78364
99	17	16.98	0.45594
100	17	21.64	0.19891
Combined P-value for all tests (Using KS method)			0.81407

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	48.00	0.55393
2	50	53.62	0.33714
3	50	57.51	0.21704

4	50	62.30	0.11368
5	50	54.34	0.31253
6	50	49.48	0.49417
7	50	44.14	0.70632
8	50	64.24	0.08494
9	50	53.09	0.35599
10	50	35.88	0.93369
11	50	39.55	0.85541
12	50	38.41	0.88399
13	50	52.01	0.39544
14	50	60.91	0.13864
15	50	47.45	0.57641
16	50	47.68	0.56688
17	50	47.13	0.58926
18	50	46.41	0.61812
19	50	48.07	0.55112
20	50	50.58	0.45067
21	50	43.72	0.72200
22	50	81.49	0.00324
23	50	49.35	0.49943
24	50	48.60	0.52958
25	50	62.25	0.11451
26	50	46.06	0.63237
27	50	39.16	0.86573
28	50	45.44	0.65679
29	50	67.78	0.04774
30	50	49.41	0.49714
31	50	38.04	0.89241
32	50	49.24	0.50390
33	50	41.61	0.79481
34	50	75.95	0.01043
35	50	43.98	0.71232
36	50	58.69	0.18710
37	50	67.71	0.04827
38	50	50.90	0.43803
39	50	52.67	0.37130
40	50	65.16	0.07350
41	50	46.93	0.59733
42	50	40.03	0.84233
43	50	56.64	0.24099
44	50	63.27	0.09841
45	50	48.51	0.53329
46	50	57.70	0.21206
47	50	45.60	0.65035
48	50	40.01	0.84282
49	50	58.96	0.18054
50	50	59.13	0.17656
51	50	37.39	0.90630
52	50	44.15	0.70619

53	50	41.30	0.80470
54	50	43.34	0.73593
55	50	33.68	0.96288
56	50	40.02	0.84274
57	50	47.53	0.57287
58	50	54.45	0.30887
59	50	49.63	0.48805
60	50	47.97	0.55523
61	50	38.97	0.87052
62	50	52.44	0.37941
63	50	43.25	0.73923
64	50	80.52	0.00400
65	50	46.29	0.62290
66	50	56.97	0.23183
67	50	42.25	0.77379
68	50	69.17	0.03751
69	50	32.98	0.96975
70	50	57.53	0.21658
71	50	84.35	0.00171
72	50	42.82	0.75420
73	50	43.97	0.71266
74	50	52.98	0.35976
75	50	47.00	0.59443
76	50	40.47	0.82979
77	50	61.39	0.12972
78	50	46.13	0.62933
79	50	55.51	0.27500
80	50	44.17	0.70541
81	50	52.50	0.37744
82	50	42.98	0.74875
83	50	45.76	0.64427
84	50	43.49	0.73053
85	50	47.68	0.56707
86	50	58.54	0.19060
87	50	50.97	0.43533
88	50	40.74	0.82197
89	50	38.76	0.87555
90	50	46.69	0.60699
91	50	43.20	0.74084
92	50	52.99	0.35965
93	50	59.34	0.17172
94	50	49.58	0.49005
95	50	63.57	0.09405
96	50	42.89	0.75198
97	50	39.90	0.84609
98	50	43.68	0.72364
99	50	40.82	0.81959
100	50	41.44	0.80018
Combined P-value for all tests			0.27725

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	8.82	0.71799
2	12	12.35	0.41823
3	12	11.44	0.49199
4	12	17.80	0.12180
5	12	8.17	0.77190
6	12	18.49	0.10153
7	12	10.70	0.55440
8	12	11.30	0.50335
9	12	15.04	0.23936
10	12	9.04	0.69980
11	12	14.12	0.29338
12	12	7.23	0.84225
13	12	9.95	0.62002
14	12	17.64	0.12698
15	12	24.94	0.01513
16	12	8.96	0.70607
17	12	16.62	0.16464
18	12	24.04	0.02006
19	12	17.87	0.11957
20	12	17.69	0.12545
21	12	10.50	0.57237
22	12	8.33	0.75894
23	12	17.49	0.13204
24	12	15.01	0.24099
25	12	15.86	0.19766
26	12	12.63	0.39686
27	12	4.23	0.97891
28	12	11.38	0.49651
29	12	18.11	0.11237
30	12	6.93	0.86201
31	12	9.37	0.67082
32	12	11.90	0.45408
33	12	14.52	0.26856
34	12	10.48	0.57350
35	12	19.24	0.08296
36	12	12.08	0.43919
37	12	12.13	0.43516

38	12	10.77	0.54832
39	12	5.56	0.93667
40	12	10.74	0.55090
41	12	20.71	0.05471
42	12	10.93	0.53481
43	12	12.15	0.43380
44	12	10.89	0.53841
45	12	6.66	0.87895
46	12	8.49	0.74572
47	12	10.49	0.57267
48	12	4.62	0.96935
49	12	6.31	0.89943
50	12	9.64	0.64710
51	12	3.60	0.98961
52	12	3.52	0.99063
53	12	11.43	0.49260
54	12	14.16	0.29035
55	12	6.55	0.88598
56	12	10.22	0.59707
57	12	13.61	0.32605
58	12	12.60	0.39869
59	12	13.22	0.35339
60	12	13.21	0.35371
61	12	13.35	0.34444
62	12	16.39	0.17407
63	12	8.56	0.73991
64	12	11.97	0.44788
65	12	13.78	0.31519
66	12	3.69	0.98839
67	12	12.60	0.39860
68	12	11.23	0.50937
69	12	11.91	0.45321
70	12	13.29	0.34847
71	12	15.02	0.24009
72	12	5.15	0.95295
73	12	17.89	0.11906
74	12	15.89	0.19652
75	12	24.73	0.01618
76	12	20.24	0.06267
77	12	7.16	0.84699
78	12	12.99	0.37006
79	12	11.78	0.46352
80	12	10.16	0.60169
81	12	13.35	0.34391
82	12	15.40	0.22041
83	12	23.09	0.02698
84	12	8.47	0.74770
85	12	17.57	0.12925
86	12	19.57	0.07566

87	12	2.87	0.99638
88	12	16.65	0.16334
89	12	20.73	0.05449
90	12	14.36	0.27827
91	12	13.36	0.34315
92	12	10.23	0.59546
93	12	5.85	0.92331
94	12	12.15	0.43380
95	12	10.64	0.56009
96	12	4.71	0.96698
97	12	20.23	0.06292
98	12	11.59	0.47939
99	12	12.63	0.39639
100	12	16.03	0.19009
Combined P-value for all tests (Using KS method)			0.11299

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	13.24	0.35208
2	12	7.55	0.81889
3	12	16.15	0.18461
4	12	11.46	0.48985
5	12	10.36	0.58435
6	12	17.16	0.14385
7	12	16.61	0.16503
8	12	6.25	0.90278
9	12	3.78	0.98703
10	12	13.78	0.31511
11	12	12.40	0.41432
12	12	14.23	0.28597
13	12	10.32	0.58768
14	12	12.01	0.44504
15	12	10.57	0.56579
16	12	6.10	0.91117
17	12	12.04	0.44274
18	12	8.47	0.74702
19	12	16.46	0.17090
20	12	18.19	0.10993
21	12	14.07	0.29618
22	12	27.06	0.00757
23	12	14.20	0.28824
24	12	6.15	0.90851
25	12	5.84	0.92377
26	12	13.74	0.31766
27	12	10.82	0.54446
28	12	16.64	0.16346
29	12	27.24	0.00714
30	12	4.88	0.96185
31	12	10.66	0.55803
32	12	15.54	0.21306

33	12	11.81	0.46133
34	12	17.11	0.14565
35	12	7.65	0.81175
36	12	9.79	0.63449
37	12	5.12	0.95392
38	12	11.61	0.47738
39	12	13.06	0.36484
40	12	10.34	0.58598
41	12	9.86	0.62789
42	12	7.62	0.81403
43	12	5.64	0.93331
44	12	3.65	0.98897
45	12	4.26	0.97822
46	12	11.49	0.48762
47	12	17.43	0.13403
48	12	3.45	0.99142
49	12	14.34	0.27961
50	12	10.76	0.54971
51	12	11.09	0.52105
52	12	8.00	0.78503
53	12	15.14	0.23387
54	12	7.99	0.78612
55	12	13.14	0.35885
56	12	10.28	0.59118
57	12	9.82	0.63169
58	12	11.44	0.49124
59	12	16.05	0.18881
60	12	11.16	0.51537
61	12	14.58	0.26521
62	12	8.18	0.77070
63	12	24.97	0.01497
64	12	6.92	0.86268
65	12	9.15	0.68995
66	12	12.15	0.43360
67	12	9.05	0.69865
68	12	16.16	0.18408
69	12	22.05	0.03699
70	12	19.54	0.07622
71	12	6.88	0.86557
72	12	10.21	0.59767
73	12	10.38	0.58276
74	12	11.70	0.46977
75	12	18.32	0.10645
76	12	18.82	0.09297
77	12	8.09	0.77815
78	12	17.56	0.12980
79	12	21.64	0.04178
80	12	12.56	0.40214
81	12	7.52	0.82132
82	12	5.56	0.93680
83	12	8.59	0.73765
84	12	13.14	0.35922
85	12	14.76	0.25457
86	12	13.42	0.33916
87	12	11.29	0.50450
88	12	21.32	0.04591

89	12	9.22	0.68404
90	12	13.24	0.35211
91	12	17.67	0.12596
92	12	19.72	0.07262
93	12	8.15	0.77356
94	12	12.58	0.40046
95	12	15.79	0.20116
96	12	14.01	0.30038
97	12	8.89	0.71216
98	12	8.28	0.76288
99	12	25.08	0.01443
100	12	7.04	0.85527
Combined P-value for all tests (Using KS method)			0.94134

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)	0.29987	1.00000
Opening Score (Dealer)	0.81407	1.00000
Dealer's Final Score	0.27725	1.00000
Player Cards Rank	0.11299	0.56494
Dealer Cards Rank	0.94134	1.00000
Combined P-Value using Holm's Method		0.56494

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 December 2024

Signed:



Alvin Rizaldi
Chief Executive Officer
iTech Labs Australia

Date: 16 December 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.