



Blackjack Cards Analysis – December 2023

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **December 01, 2023 to December 31, 2023** 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	18.43	0.36225
2	17	26.19	0.07109
3	17	7.79	0.97086
4	17	15.66	0.54783
5	17	19.71	0.28907
6	17	16.12	0.51559
7	17	12.70	0.75619
8	17	13.73	0.68584
9	17	31.21	0.01884
10	17	13.12	0.72794
11	17	18.74	0.34376
12	17	18.37	0.36560
13	17	12.28	0.78303
14	17	17.73	0.40637
15	17	19.34	0.30952
16	17	29.10	0.03360
17	17	12.43	0.77348
18	17	8.88	0.94406
19	17	15.82	0.53648
20	17	26.71	0.06252
21	17	24.47	0.10718

22	17	28.63	0.03812
23	17	19.99	0.27457
24	17	21.87	0.18980
25	17	5.71	0.99495
26	17	24.80	0.09920
27	17	13.03	0.73445
28	17	15.42	0.56558
29	17	18.30	0.37007
30	17	24.48	0.10688
31	17	15.50	0.55925
32	17	17.10	0.44779
33	17	17.73	0.40630
34	17	22.20	0.17720
35	17	16.72	0.47317
36	17	19.18	0.31808
37	17	15.18	0.58260
38	17	15.58	0.55343
39	17	15.78	0.53915
40	17	14.68	0.61845
41	17	7.41	0.97765
42	17	12.09	0.79482
43	17	19.32	0.31044
44	17	6.71	0.98697
45	17	17.85	0.39846
46	17	16.02	0.52255
47	17	14.69	0.61803
48	17	20.06	0.27098
49	17	10.22	0.89413
50	17	25.58	0.08246
51	17	12.06	0.79652
52	17	12.59	0.76332
53	17	20.51	0.24889
54	17	18.63	0.35037
55	17	15.42	0.56515
56	17	24.05	0.11806
57	17	20.10	0.26905
58	17	25.81	0.07808
59	17	17.78	0.40258
60	17	9.43	0.92596
61	17	21.39	0.20936
62	17	22.52	0.16540
63	17	24.27	0.11220
64	17	20.96	0.22829
65	17	18.52	0.35655
66	17	14.00	0.66685
67	17	10.32	0.88957
68	17	17.06	0.45019
69	17	10.17	0.89624
70	17	12.88	0.74389

71	17	10.51	0.88102
72	17	27.02	0.05778
73	17	21.73	0.19548
74	17	18.18	0.37742
75	17	18.83	0.33811
76	17	10.18	0.89588
77	17	9.28	0.93108
78	17	10.13	0.89805
79	17	7.58	0.97475
80	17	11.22	0.84516
81	17	20.11	0.26876
82	17	20.79	0.23562
83	17	32.92	0.01154
84	17	17.88	0.39627
85	17	15.17	0.58333
86	17	11.00	0.85669
87	17	18.99	0.32930
88	17	23.82	0.12453
89	17	15.33	0.57139
90	17	11.12	0.85044
91	17	21.21	0.21693
92	17	15.35	0.56996
93	17	14.28	0.64714
94	17	14.81	0.60883
95	17	6.53	0.98884
96	17	12.18	0.78893
97	17	9.70	0.91579
98	17	12.62	0.76107
99	17	18.13	0.38063
100	17	14.40	0.63875
Combined P-value for all tests (Using KS method)			0.92933

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 are sufficient data.

1.2 Dealer's opening score (from first two cards):

Test No.	DOF	ChiSqr	P-Value
1	17	10.14	0.89751
2	17	16.76	0.47087
3	17	19.01	0.32806
4	17	8.08	0.96473
5	17	13.02	0.73488
6	17	15.02	0.59383
7	17	13.74	0.68570
8	17	6.77	0.98634
9	17	15.46	0.56220
10	17	19.73	0.28836
11	17	21.98	0.18560
12	17	14.89	0.60329

13	17	18.90	0.33448
14	17	15.92	0.52920
15	17	20.56	0.24667
16	17	20.12	0.26829
17	17	14.58	0.62596
18	17	18.77	0.34164
19	17	16.37	0.49782
20	17	35.58	0.00521
21	17	37.25	0.00311
22	17	15.99	0.52429
23	17	14.58	0.62585
24	17	26.44	0.06686
25	17	10.35	0.88819
26	17	14.07	0.66198
27	17	22.15	0.17899
28	17	16.41	0.49491
29	17	14.70	0.61737
30	17	12.99	0.73707
31	17	19.19	0.31795
32	17	6.43	0.98979
33	17	30.27	0.02446
34	17	16.99	0.45520
35	17	14.72	0.61529
36	17	17.91	0.39481
37	17	22.78	0.15653
38	17	10.66	0.87361
39	17	12.26	0.78406
40	17	10.87	0.86303
41	17	14.64	0.62156
42	17	11.84	0.80965
43	17	13.88	0.67570
44	17	14.58	0.62600
45	17	21.54	0.20303
46	17	25.52	0.08360
47	17	19.01	0.32784
48	17	19.35	0.30880
49	17	22.73	0.15828
50	17	19.85	0.28175
51	17	17.15	0.44407
52	17	23.86	0.12330
53	17	16.59	0.48258
54	17	12.23	0.78610
55	17	14.63	0.62199
56	17	11.15	0.84880
57	17	15.69	0.54622
58	17	14.68	0.61864
59	17	16.62	0.48051
60	17	18.69	0.34685
61	17	13.41	0.70853

62	17	10.88	0.86263
63	17	17.64	0.41176
64	17	22.85	0.15412
65	17	8.89	0.94371
66	17	24.04	0.11848
67	17	15.04	0.59268
68	17	12.11	0.79342
69	17	8.38	0.95769
70	17	31.14	0.01922
71	17	26.06	0.07339
72	17	6.25	0.99135
73	17	19.25	0.31439
74	17	27.41	0.05233
75	17	20.02	0.27328
76	17	20.10	0.26922
77	17	18.72	0.34501
78	17	14.69	0.61746
79	17	19.14	0.32031
80	17	15.96	0.52698
81	17	17.63	0.41271
82	17	13.11	0.72888
83	17	19.23	0.31526
84	17	18.90	0.33429
85	17	27.06	0.05724
86	17	14.41	0.63800
87	17	24.53	0.10567
88	17	9.02	0.93954
89	17	23.05	0.14757
90	17	24.84	0.09824
91	17	12.46	0.77138
92	17	10.77	0.86812
93	17	15.65	0.54905
94	17	22.94	0.15130
95	17	11.43	0.83314
96	17	10.37	0.88752
97	17	14.36	0.64129
98	17	19.08	0.32383
99	17	11.47	0.83086
100	17	22.61	0.16224
Combined P-value for all tests (Using KS method)			0.87115

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 are 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	71.92	0.02280
2	50	75.05	0.01247
3	50	50.98	0.43504

4	50	34.27	0.95616
5	50	47.51	0.57375
6	50	31.44	0.98141
7	50	51.20	0.42645
8	50	38.24	0.88793
9	50	60.17	0.15368
10	50	65.72	0.06720
11	50	42.81	0.75449
12	50	60.14	0.15433
13	50	58.99	0.17976
14	50	45.25	0.66419
15	50	47.33	0.58108
16	50	53.56	0.33926
17	50	59.54	0.16717
18	50	55.38	0.27905
19	50	54.43	0.30960
20	50	60.49	0.14709
21	50	53.24	0.35046
22	50	62.34	0.11312
23	50	53.26	0.34987
24	50	39.52	0.85615
25	50	42.24	0.77407
26	50	49.31	0.50115
27	50	46.26	0.62417
28	50	36.48	0.92351
29	50	33.74	0.96221
30	50	52.54	0.37590
31	50	28.69	0.99331
32	50	34.58	0.95235
33	50	52.03	0.39482
34	50	42.45	0.76688
35	50	42.53	0.76439
36	50	52.47	0.37865
37	50	43.30	0.73718
38	50	49.85	0.47939
39	50	41.39	0.80174
40	50	42.87	0.75239
41	50	35.23	0.94355
42	50	47.62	0.56927
43	50	42.61	0.76141
44	50	40.13	0.83965
45	50	63.78	0.09119
46	50	41.98	0.78274
47	50	41.81	0.78838
48	50	56.26	0.25223
49	50	56.31	0.25076
50	50	46.20	0.62676
51	50	67.80	0.04757
52	50	77.26	0.00798

53	50	54.06	0.32201
54	50	68.95	0.03901
55	50	55.57	0.27308
56	50	52.29	0.38494
57	50	39.87	0.84678
58	50	30.35	0.98733
59	50	54.14	0.31925
60	50	58.59	0.18944
61	50	54.99	0.29140
62	50	50.00	0.47343
63	50	61.85	0.12139
64	50	60.12	0.15472
65	50	68.00	0.04595
66	50	52.74	0.36855
67	50	67.55	0.04960
68	50	47.25	0.58439
69	50	43.81	0.71863
70	50	55.53	0.27435
71	50	36.84	0.91705
72	50	42.28	0.77280
73	50	58.44	0.19311
74	50	47.55	0.57231
75	50	49.33	0.50024
76	50	55.30	0.28132
77	50	38.62	0.87899
78	50	42.42	0.76797
79	50	68.21	0.04434
80	50	43.27	0.73828
81	50	46.58	0.61131
82	50	43.77	0.72016
83	50	48.27	0.54315
84	50	64.50	0.08150
85	50	32.96	0.96993
86	50	47.09	0.59080
87	50	46.44	0.61714
88	50	58.10	0.20151
89	50	45.96	0.63617
90	50	36.56	0.92206
91	50	42.57	0.76302
92	50	63.34	0.09747
93	50	37.26	0.90884
94	50	53.58	0.33868
95	50	57.13	0.22747
96	50	50.64	0.44798
97	50	34.74	0.95035
98	50	42.01	0.78189
99	50	58.99	0.17991
100	50	59.98	0.15764
Combined P-value for all tests			0.71903

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 are 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	16.87	0.15451
2	12	8.15	0.77312
3	12	26.56	0.00895
4	12	8.94	0.70782
5	12	13.20	0.35484
6	12	12.88	0.37810
7	12	5.08	0.95515
8	12	11.45	0.49088
9	12	17.79	0.12233
10	12	14.58	0.26530
11	12	12.17	0.43220
12	12	17.02	0.14872
13	12	7.60	0.81576
14	12	7.35	0.83357
15	12	18.23	0.10886
16	12	7.66	0.81134
17	12	8.97	0.70565
18	12	12.11	0.43655
19	12	11.77	0.46432
20	12	25.69	0.01186
21	12	8.62	0.73458
22	12	10.84	0.54299
23	12	14.82	0.25164
24	12	11.56	0.48134
25	12	10.33	0.58719
26	12	15.57	0.21188
27	12	17.71	0.12493
28	12	9.13	0.69160
29	12	19.22	0.08331
30	12	8.80	0.71952
31	12	16.66	0.16286
32	12	9.91	0.62395
33	12	22.44	0.03288
34	12	6.10	0.91107
35	12	13.65	0.32342
36	12	7.12	0.84985

37	12	12.67	0.39357
38	12	8.65	0.73265
39	12	8.58	0.73871
40	12	9.82	0.63158
41	12	7.86	0.79578
42	12	26.42	0.00937
43	12	9.71	0.64098
44	12	10.56	0.56705
45	12	10.53	0.56981
46	12	8.63	0.73388
47	12	7.35	0.83364
48	12	7.61	0.81488
49	12	20.33	0.06102
50	12	12.05	0.44183
51	12	16.08	0.18773
52	12	15.17	0.23253
53	12	14.69	0.25885
54	12	11.67	0.47239
55	12	18.51	0.10104
56	12	10.85	0.54160
57	12	10.46	0.57558
58	12	16.14	0.18470
59	12	10.65	0.55916
60	12	12.38	0.41535
61	12	16.91	0.15292
62	12	7.46	0.82570
63	12	13.69	0.32086
64	12	9.84	0.63013
65	12	6.87	0.86640
66	12	6.76	0.87296
67	12	7.85	0.79698
68	12	4.86	0.96260
69	12	6.76	0.87329
70	12	14.38	0.27699
71	12	11.75	0.46629
72	12	10.52	0.57076
73	12	30.82	0.00210
74	12	12.43	0.41154
75	12	9.41	0.66727
76	12	18.67	0.09693
77	12	9.34	0.67396
78	12	17.95	0.11722
79	12	13.37	0.34272
80	12	6.35	0.89733
81	12	15.83	0.19929
82	12	23.51	0.02370
83	12	11.58	0.48017
84	12	10.46	0.57591
85	12	13.77	0.31569

86	12	17.16	0.14352
87	12	6.28	0.90122
88	12	25.17	0.01403
89	12	9.99	0.61690
90	12	11.45	0.49040
91	12	13.29	0.34866
92	12	7.50	0.82317
93	12	22.62	0.03114
94	12	12.39	0.41501
95	12	13.93	0.30527
96	12	8.64	0.73368
97	12	2.93	0.99601
98	12	10.81	0.54562
99	12	16.41	0.17331
100	12	15.02	0.24008
Combined P-value for all tests (Using KS method)			0.89610

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 are sufficient data.

2.2 Blackjack rank statistics for all dealer cards:

Test No.	DOF	ChiSqr	P-Value
1	12	10.54	0.56839
2	12	15.45	0.21767
3	12	8.64	0.73333
4	12	10.27	0.59268
5	12	10.22	0.59662
6	12	8.47	0.74712
7	12	9.00	0.70306
8	12	9.26	0.68032
9	12	16.82	0.15640
10	12	13.02	0.36744
11	12	8.09	0.77802
12	12	11.72	0.46854
13	12	6.86	0.86666
14	12	4.19	0.97977
15	12	10.54	0.56887
16	12	7.34	0.83460
17	12	11.48	0.48817
18	12	15.90	0.19572
19	12	13.93	0.30494
20	12	14.88	0.24818
21	12	13.67	0.32198
22	12	8.51	0.74411
23	12	14.61	0.26369
24	12	17.21	0.14187
25	12	7.28	0.83825
26	12	9.55	0.65577
27	12	8.66	0.73133
28	12	4.51	0.97237
29	12	15.03	0.23956
30	12	10.57	0.56595

31	12	3.16	0.99428
32	12	16.33	0.17656
33	12	21.60	0.04226
34	12	10.14	0.60386
35	12	8.04	0.78239
36	12	11.42	0.49318
37	12	12.85	0.38026
38	12	13.60	0.32711
39	12	13.24	0.35195
40	12	17.97	0.11654
41	12	5.95	0.91883
42	12	14.45	0.27314
43	12	13.67	0.32241
44	12	36.16	0.00030
45	12	15.50	0.21520
46	12	10.30	0.58975
47	12	13.66	0.32294
48	12	14.17	0.28983
49	12	7.14	0.84812
50	12	11.12	0.51849
51	12	10.26	0.59347
52	12	10.68	0.55622
53	12	11.18	0.51339
54	12	8.80	0.71983
55	12	21.65	0.04163
56	12	3.14	0.99449
57	12	13.87	0.30879
58	12	7.71	0.80706
59	12	12.57	0.40140
60	12	20.62	0.05631
61	12	17.78	0.12247
62	12	11.88	0.45524
63	12	9.78	0.63543
64	12	16.80	0.15722
65	12	9.53	0.65729
66	12	16.97	0.15067
67	12	10.01	0.61548
68	12	14.61	0.26337
69	12	10.89	0.53798
70	12	18.08	0.11330
71	12	8.65	0.73233
72	12	7.73	0.80612
73	12	10.48	0.57367
74	12	12.85	0.37989
75	12	15.35	0.22277
76	12	17.32	0.13792
77	12	12.43	0.41156
78	12	17.13	0.14470
79	12	12.33	0.41928
80	12	11.54	0.48298
81	12	9.50	0.66012
82	12	21.88	0.03894
83	12	7.68	0.80983
84	12	12.15	0.43401
85	12	26.78	0.00832
86	12	12.38	0.41580

87	12	12.77	0.38578
88	12	8.33	0.75860
89	12	15.27	0.22697
90	12	9.17	0.68802
91	12	8.36	0.75645
92	12	16.44	0.17184
93	12	6.65	0.87971
94	12	13.56	0.32965
95	12	9.87	0.62763
96	12	7.03	0.85579
97	12	11.35	0.49952
98	12	13.03	0.36653
99	12	8.98	0.70455
100	12	12.36	0.41739
Combined P-value for all tests (Using KS method)			0.67205

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 are sufficient data.

4. Summary of the analysis of blackjack tests

The Blackjack cards analysis completes 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 indication for statistical randomness.

Combination of p-values using Holm's Method		
Test	P-Value	P-Adjusted
Opening Score (Player)	0.92933	1.00000
Opening Score (Dealer)	0.87115	1.00000
Dealer's Final Score	0.71903	1.00000
Player Cards Rank	0.89610	1.00000
Dealer Cards Rank	0.67205	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 deck 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: 25 January 2024

Signed:



Alvin Rizaldi
Chief Executive Officer
iTech Labs Australia
Date: 25 January 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.