



## Blackjack Cards Analysis – November 2023

### The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **November 01, 2023 to November 30, 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	17.64	0.41164
2	17	13.99	0.66783
3	17	13.72	0.68652
4	17	30.99	0.02003
5	17	8.27	0.96043
6	17	16.66	0.47789
7	17	7.11	0.98206
8	17	20.40	0.25436
9	17	29.59	0.02945
10	17	16.49	0.48946
11	17	19.28	0.31259
12	17	11.19	0.84654
13	17	15.80	0.53787
14	17	20.18	0.26521
15	17	20.30	0.25905
16	17	29.48	0.03035
17	17	21.90	0.18868
18	17	11.53	0.82748
19	17	11.41	0.83445
20	17	18.36	0.36678
21	17	20.21	0.26358

22	17	11.33	0.83879
23	17	8.00	0.96649
24	17	20.31	0.25844
25	17	21.79	0.19298
26	17	17.89	0.39561
27	17	5.43	0.99627
28	17	20.23	0.26259
29	17	18.50	0.35784
30	17	16.64	0.47926
31	17	15.96	0.52666
32	17	13.85	0.67764
33	17	15.89	0.53136
34	17	13.49	0.70313
35	17	8.97	0.94113
36	17	12.56	0.76493
37	17	16.30	0.50299
38	17	14.62	0.62308
39	17	18.81	0.33943
40	17	11.02	0.85529
41	17	15.10	0.58797
42	17	18.41	0.36327
43	17	12.26	0.78400
44	17	11.90	0.80587
45	17	14.51	0.63053
46	17	15.61	0.55153
47	17	15.22	0.57984
48	17	13.64	0.69253
49	17	12.19	0.78875
50	17	21.09	0.22233
51	17	15.36	0.56955
52	17	14.93	0.60060
53	17	16.38	0.49715
54	17	8.05	0.96552
55	17	19.18	0.31857
56	17	20.37	0.25566
57	17	20.77	0.23663
58	17	6.68	0.98735
59	17	23.56	0.13190
60	17	14.21	0.65220
61	17	14.58	0.62564
62	17	17.71	0.40746
63	17	24.20	0.11412
64	17	21.67	0.19760
65	17	12.27	0.78381
66	17	15.48	0.56075
67	17	19.29	0.31219
68	17	7.85	0.96962
69	17	14.33	0.64342
70	17	12.89	0.74325

71	17	11.68	0.81917
72	17	14.72	0.61528
73	17	21.63	0.19951
74	17	19.30	0.31170
75	17	11.34	0.83809
76	17	14.06	0.66257
77	17	16.03	0.52190
78	17	30.47	0.02312
79	17	23.20	0.14291
80	17	16.63	0.47954
81	17	20.42	0.25319
82	17	25.48	0.08445
83	17	12.38	0.77668
84	17	24.24	0.11308
85	17	12.20	0.78804
86	17	14.11	0.65924
87	17	21.49	0.20505
88	17	29.58	0.02957
89	17	19.88	0.28041
90	17	13.98	0.66861
91	17	29.20	0.03272
92	17	19.22	0.31586
93	17	9.64	0.91784
94	17	15.85	0.53444
95	17	21.99	0.18526
96	17	14.21	0.65237
97	17	9.73	0.91457
98	17	16.35	0.49915
99	17	18.68	0.34721
100	17	19.15	0.31985
Combined P-value for all tests (Using KS method)			0.60618

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	14.06	0.66257
2	17	17.76	0.40429
3	17	13.02	0.73486
4	17	23.75	0.12628
5	17	24.86	0.09799
6	17	24.68	0.10205
7	17	23.86	0.12334
8	17	11.53	0.82764
9	17	15.18	0.58216
10	17	22.47	0.16717
11	17	13.13	0.72724
12	17	12.26	0.78384

13	17	13.50	0.70202
14	17	15.21	0.58003
15	17	25.39	0.08631
16	17	15.60	0.55228
17	17	15.02	0.59401
18	17	12.06	0.79647
19	17	19.09	0.32358
20	17	24.50	0.10644
21	17	9.27	0.93150
22	17	15.95	0.52753
23	17	18.71	0.34563
24	17	16.36	0.49836
25	17	15.20	0.58138
26	17	10.64	0.87477
27	17	18.07	0.38413
28	17	21.13	0.22054
29	17	15.97	0.52619
30	17	16.15	0.51333
31	17	9.42	0.92602
32	17	6.63	0.98788
33	17	14.30	0.64570
34	17	19.16	0.31950
35	17	10.06	0.90102
36	17	5.36	0.99654
37	17	22.10	0.18101
38	17	14.30	0.64606
39	17	10.04	0.90175
40	17	19.48	0.30153
41	17	9.05	0.93882
42	17	12.95	0.73934
43	17	28.60	0.03840
44	17	25.44	0.08535
45	17	17.58	0.41575
46	17	19.34	0.30933
47	17	14.68	0.61839
48	17	14.65	0.62063
49	17	22.68	0.15997
50	17	19.83	0.28303
51	17	23.78	0.12559
52	17	10.46	0.88331
53	17	30.50	0.02293
54	17	20.73	0.23868
55	17	12.46	0.77167
56	17	21.98	0.18551
57	17	21.30	0.21305
58	17	9.63	0.91857
59	17	9.32	0.92963
60	17	19.00	0.32874
61	17	14.02	0.66580

62	17	13.88	0.67553
63	17	13.81	0.68016
64	17	11.20	0.84624
65	17	16.24	0.50678
66	17	18.40	0.36381
67	17	21.53	0.20367
68	17	37.01	0.00336
69	17	17.65	0.41106
70	17	26.54	0.06524
71	17	11.05	0.85400
72	17	16.48	0.49001
73	17	14.84	0.60729
74	17	17.72	0.40697
75	17	27.13	0.05614
76	17	7.91	0.96844
77	17	14.74	0.61433
78	17	10.28	0.89136
79	17	27.88	0.04638
80	17	22.63	0.16157
81	17	19.10	0.32289
82	17	19.03	0.32670
83	17	17.31	0.43338
84	17	17.42	0.42626
85	17	18.32	0.36870
86	17	14.24	0.65010
87	17	16.55	0.48529
88	17	24.34	0.11037
89	17	16.00	0.52373
90	17	12.89	0.74339
91	17	12.54	0.76618
92	17	26.20	0.07086
93	17	13.96	0.67017
94	17	24.22	0.11361
95	17	11.03	0.85511
96	17	13.09	0.73022
97	17	14.78	0.61140
98	17	5.89	0.99387
99	17	21.13	0.22065
100	17	27.09	0.05675
Combined P-value for all tests (Using KS method)			0.98949

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	41.96	0.78358
2	50	57.60	0.21456
3	50	49.86	0.47911

4	50	59.41	0.17010
5	50	64.94	0.07609
6	50	43.62	0.72576
7	50	62.25	0.11463
8	50	54.49	0.30755
9	50	48.12	0.54927
10	50	57.67	0.21280
11	50	44.28	0.70138
12	50	56.14	0.25573
13	50	59.82	0.16104
14	50	33.98	0.95960
15	50	30.97	0.98418
16	50	45.78	0.64330
17	50	39.28	0.86262
18	50	43.91	0.71512
19	50	41.04	0.81269
20	50	40.67	0.82397
21	50	36.11	0.92994
22	50	62.12	0.11668
23	50	38.39	0.88445
24	50	49.72	0.48462
25	50	53.12	0.35504
26	50	38.36	0.88517
27	50	53.63	0.33693
28	50	43.88	0.71616
29	50	49.44	0.49587
30	50	54.19	0.31784
31	50	47.42	0.57737
32	50	59.18	0.17554
33	50	56.79	0.23683
34	50	38.83	0.87379
35	50	50.84	0.44044
36	50	47.73	0.56477
37	50	44.56	0.69078
38	50	44.81	0.68130
39	50	48.60	0.52974
40	50	49.30	0.50134
41	50	37.72	0.89931
42	50	58.58	0.18970
43	50	32.15	0.97660
44	50	47.76	0.56379
45	50	70.44	0.02988
46	50	73.12	0.01818
47	50	50.52	0.45298
48	50	37.25	0.90910
49	50	47.28	0.58314
50	50	40.84	0.81870
51	50	54.98	0.29172
52	50	51.25	0.42424

53	50	49.52	0.49259
54	50	72.06	0.02218
55	50	53.01	0.35879
56	50	59.04	0.17871
57	50	50.76	0.44330
58	50	33.28	0.96694
59	50	59.16	0.17582
60	50	50.93	0.43666
61	50	49.08	0.51025
62	50	43.65	0.72461
63	50	57.84	0.20834
64	50	48.07	0.55124
65	50	56.51	0.24472
66	50	41.38	0.80204
67	50	44.38	0.69758
68	50	28.78	0.99305
69	50	46.91	0.59807
70	50	57.28	0.22328
71	50	58.17	0.19993
72	50	52.36	0.38237
73	50	40.04	0.84202
74	50	61.41	0.12931
75	50	58.18	0.19967
76	50	48.93	0.51641
77	50	38.19	0.88897
78	50	50.42	0.45697
79	50	33.35	0.96627
80	50	40.79	0.82034
81	50	59.57	0.16660
82	50	46.85	0.60042
83	50	54.49	0.30781
84	50	53.55	0.33978
85	50	43.49	0.73062
86	50	33.84	0.96108
87	50	37.88	0.89583
88	50	49.39	0.49797
89	50	48.69	0.52623
90	50	52.05	0.39419
91	50	89.13	0.00056
92	50	55.75	0.26750
93	50	27.77	0.99546
94	50	52.76	0.36788
95	50	44.36	0.69818
96	50	67.09	0.05364
97	50	56.22	0.25347
98	50	52.49	0.37759
99	50	46.12	0.62986
100	50	65.12	0.07390
Combined P-value for all tests			0.83909

*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	14.73	0.25630
2	12	12.24	0.42630
3	12	12.65	0.39463
4	12	15.04	0.23915
5	12	10.61	0.56269
6	12	9.49	0.66020
7	12	13.36	0.34333
8	12	15.81	0.19990
9	12	26.27	0.00983
10	12	12.09	0.43853
11	12	11.94	0.45029
12	12	4.10	0.98153
13	12	11.21	0.51061
14	12	6.61	0.88201
15	12	23.35	0.02493
16	12	7.94	0.79006
17	12	16.20	0.18241
18	12	10.15	0.60323
19	12	12.09	0.43861
20	12	6.63	0.88091
21	12	18.01	0.11526
22	12	11.94	0.45071
23	12	9.91	0.62385
24	12	14.72	0.25707
25	12	7.70	0.80795
26	12	11.11	0.51927
27	12	7.53	0.82096
28	12	18.78	0.09400
29	12	5.97	0.91779
30	12	11.27	0.50581
31	12	9.98	0.61760
32	12	12.69	0.39166
33	12	6.23	0.90396
34	12	7.02	0.85612
35	12	15.34	0.22337
36	12	18.77	0.09429



37	12	11.40	0.49517
38	12	15.05	0.23850
39	12	23.92	0.02089
40	12	10.52	0.57071
41	12	12.79	0.38450
42	12	8.86	0.71500
43	12	11.60	0.47805
44	12	12.28	0.42377
45	12	14.89	0.24744
46	12	13.13	0.35948
47	12	11.58	0.48033
48	12	16.19	0.18280
49	12	8.46	0.74799
50	12	5.95	0.91859
51	12	6.70	0.87649
52	12	7.21	0.84316
53	12	17.46	0.13305
54	12	5.63	0.93348
55	12	18.51	0.10093
56	12	11.62	0.47660
57	12	10.32	0.58776
58	12	10.57	0.56626
59	12	6.70	0.87681
60	12	27.22	0.00719
61	12	12.09	0.43870
62	12	5.43	0.94197
63	12	14.89	0.24770
64	12	11.93	0.45093
65	12	9.56	0.65445
66	12	10.57	0.56635
67	12	14.20	0.28842
68	12	4.29	0.97768
69	12	12.38	0.41600
70	12	12.17	0.43186
71	12	13.32	0.34608
72	12	7.59	0.81628
73	12	16.78	0.15792
74	12	7.60	0.81545
75	12	16.13	0.18545
76	12	8.92	0.70942
77	12	21.16	0.04816
78	12	7.43	0.82815
79	12	19.48	0.07752
80	12	8.20	0.76936
81	12	8.32	0.76004
82	12	6.17	0.90730
83	12	9.94	0.62128
84	12	6.92	0.86303
85	12	6.87	0.86622

86	12	25.50	0.01262
87	12	9.20	0.68583
88	12	10.72	0.55333
89	12	21.15	0.04827
90	12	6.02	0.91515
91	12	11.80	0.46161
92	12	19.71	0.07277
93	12	13.77	0.31590
94	12	11.34	0.49983
95	12	19.94	0.06818
96	12	18.96	0.08959
97	12	7.97	0.78771
98	12	7.42	0.82866
99	12	8.58	0.73843
100	12	9.11	0.69386
Combined P-value for all tests (Using KS method)			0.90441

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	7.58	0.81681
2	12	16.20	0.18207
3	12	14.72	0.25724
4	12	7.96	0.78789
5	12	9.94	0.62117
6	12	4.21	0.97930
7	12	16.54	0.16763
8	12	7.69	0.80869
9	12	11.60	0.47855
10	12	13.31	0.34714
11	12	12.76	0.38643
12	12	11.27	0.50559
13	12	8.78	0.72136
14	12	8.70	0.72850
15	12	12.77	0.38583
16	12	14.84	0.25041
17	12	8.55	0.74104
18	12	14.42	0.27476
19	12	10.15	0.60311
20	12	10.27	0.59242
21	12	13.84	0.31121
22	12	14.28	0.28332
23	12	22.19	0.03542
24	12	9.69	0.64294
25	12	5.87	0.92228
26	12	12.58	0.40022
27	12	25.11	0.01430
28	12	9.29	0.67793
29	12	12.43	0.41215
30	12	14.10	0.29467

31	12	7.73	0.80558
32	12	3.19	0.99409
33	12	11.65	0.47399
34	12	13.65	0.32386
35	12	6.71	0.87622
36	12	16.46	0.17112
37	12	9.24	0.68261
38	12	6.43	0.89269
39	12	8.60	0.73651
40	12	6.59	0.88333
41	12	19.03	0.08790
42	12	5.28	0.94780
43	12	9.02	0.70086
44	12	9.28	0.67922
45	12	10.94	0.53377
46	12	22.50	0.03225
47	12	9.06	0.69800
48	12	12.06	0.44127
49	12	25.13	0.01423
50	12	11.54	0.48362
51	12	15.96	0.19298
52	12	20.65	0.05582
53	12	8.78	0.72118
54	12	18.34	0.10575
55	12	5.31	0.94700
56	12	14.06	0.29698
57	12	12.42	0.41280
58	12	12.67	0.39355
59	12	9.93	0.62229
60	12	8.87	0.71401
61	12	15.21	0.23029
62	12	11.63	0.47622
63	12	13.20	0.35489
64	12	9.55	0.65509
65	12	7.63	0.81367
66	12	11.87	0.45580
67	12	14.76	0.25458
68	12	16.15	0.18438
69	12	12.93	0.37387
70	12	7.10	0.85110
71	12	19.58	0.07546
72	12	6.36	0.89683
73	12	11.07	0.52318
74	12	20.46	0.05895
75	12	12.49	0.40740
76	12	15.06	0.23818
77	12	14.39	0.27626
78	12	5.12	0.95387
79	12	5.18	0.95166
80	12	8.59	0.73748
81	12	9.52	0.65842
82	12	9.46	0.66351
83	12	16.80	0.15735
84	12	18.43	0.10337
85	12	10.94	0.53391
86	12	11.12	0.51901

87	12	4.26	0.97822
88	12	15.01	0.24106
89	12	13.65	0.32343
90	12	12.26	0.42483
91	12	6.91	0.86325
92	12	17.38	0.13586
93	12	9.44	0.66464
94	12	21.24	0.04703
95	12	5.59	0.93535
96	12	16.95	0.15132
97	12	10.94	0.53374
98	12	17.32	0.13784
99	12	5.98	0.91693
100	12	9.57	0.65327
Combined P-value for all tests (Using KS method)			0.99769

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)	0.60618	1.00000
Opening Score (Dealer)	0.98949	1.00000
Dealer's Final Score	0.83909	1.00000
Player Cards Rank	0.90441	1.00000
Dealer Cards Rank	0.99769	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.

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**Signed:**



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**Divya Bhargava**  
**Project Manager**  
**iTech Labs Australia**  
Date: 27 December 2023

**Signed:**



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**Alvin Rizaldi**  
**Chief Executive Officer**  
**iTech Labs Australia**  
Date: 27 December 2023

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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.