



Blackjack Cards Analysis – May 2024

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for blackjack games for the period **May 01, 2024, to May 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	19.61	0.29479
2	17	13.44	0.70621
3	17	13.70	0.68801
4	17	15.41	0.56594
5	17	14.64	0.62106
6	17	17.36	0.42992
7	17	11.67	0.81957
8	17	20.63	0.24338
9	17	25.15	0.09148
10	17	9.45	0.92525
11	17	13.81	0.68028
12	17	16.50	0.48892
13	17	19.02	0.32731
14	17	16.88	0.46239
15	17	25.46	0.08481
16	17	21.18	0.21820
17	17	11.73	0.81595
18	17	17.67	0.40982
19	17	17.61	0.41364
20	17	15.66	0.54831
21	17	14.00	0.66688

22	17	19.44	0.30368
23	17	15.39	0.56724
24	17	24.16	0.11523
25	17	21.62	0.19998
26	17	15.77	0.54006
27	17	18.86	0.33635
28	17	9.94	0.90621
29	17	34.80	0.00660
30	17	21.16	0.21909
31	17	28.08	0.04398
32	17	25.97	0.07492
33	17	22.14	0.17954
34	17	23.78	0.12560
35	17	15.18	0.58255
36	17	18.14	0.38020
37	17	15.33	0.57191
38	17	12.17	0.78995
39	17	11.89	0.80653
40	17	28.07	0.04408
41	17	9.53	0.92202
42	17	15.10	0.58859
43	17	14.89	0.60349
44	17	15.15	0.58463
45	17	15.87	0.53326
46	17	18.52	0.35698
47	17	29.36	0.03137
48	17	9.29	0.93059
49	17	18.23	0.37434
50	17	10.50	0.88151
51	17	12.98	0.73777
52	17	4.67	0.99856
53	17	12.34	0.77936
54	17	11.24	0.84404
55	17	11.33	0.83898
56	17	27.16	0.05583
57	17	11.98	0.80111
58	17	11.86	0.80838
59	17	27.20	0.05514
60	17	15.82	0.53634
61	17	14.67	0.61950
62	17	11.94	0.80397
63	17	21.80	0.19262
64	17	9.32	0.92955
65	17	16.39	0.49662
66	17	14.83	0.60808
67	17	12.57	0.76432
68	17	9.23	0.93266
69	17	12.86	0.74549
70	17	18.40	0.36410

71	17	20.46	0.25134
72	17	10.17	0.89612
73	17	15.15	0.58470
74	17	17.41	0.42669
75	17	19.47	0.30241
76	17	16.95	0.45752
77	17	11.36	0.83708
78	17	16.50	0.48864
79	17	12.66	0.75865
80	17	7.44	0.97714
81	17	15.51	0.55868
82	17	7.92	0.96822
83	17	16.03	0.52190
84	17	12.89	0.74346
85	17	15.70	0.54530
86	17	26.64	0.06351
87	17	21.52	0.20406
88	17	14.67	0.61951
89	17	30.50	0.02293
90	17	16.41	0.49532
91	17	19.86	0.28159
92	17	19.69	0.29045
93	17	17.46	0.42393
94	17	24.32	0.11087
95	17	35.54	0.00529
96	17	16.64	0.47904
97	17	19.64	0.29326
98	17	30.14	0.02536
99	17	16.11	0.51592
100	17	16.53	0.48656
Combined P-value for all tests (Using KS method)			0.86812

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	8.53	0.95382
2	17	15.18	0.58239
3	17	26.16	0.07154
4	17	11.70	0.81807
5	17	18.31	0.36956
6	17	24.65	0.10285
7	17	17.91	0.39472
8	17	12.08	0.79525
9	17	10.01	0.90324
10	17	15.04	0.59256
11	17	20.96	0.22830
12	17	16.37	0.49812

13	17	13.78	0.68230
14	17	13.52	0.70053
15	17	19.65	0.29268
16	17	16.07	0.51899
17	17	16.52	0.48736
18	17	27.78	0.04756
19	17	14.33	0.64392
20	17	20.75	0.23781
21	17	16.63	0.47937
22	17	15.43	0.56485
23	17	26.39	0.06768
24	17	16.47	0.49101
25	17	15.06	0.59113
26	17	13.25	0.71912
27	17	20.39	0.25488
28	17	16.70	0.47521
29	17	20.45	0.25210
30	17	10.29	0.89081
31	17	10.12	0.89855
32	17	25.39	0.08634
33	17	14.10	0.66009
34	17	11.80	0.81187
35	17	22.26	0.17507
36	17	17.62	0.41318
37	17	25.14	0.09162
38	17	24.60	0.10405
39	17	19.92	0.27856
40	17	24.40	0.10902
41	17	20.71	0.23957
42	17	20.30	0.25923
43	17	24.87	0.09764
44	17	17.94	0.39260
45	17	16.13	0.51490
46	17	27.68	0.04877
47	17	21.90	0.18873
48	17	14.44	0.63556
49	17	11.64	0.82122
50	17	13.72	0.68692
51	17	5.51	0.99592
52	17	8.13	0.96367
53	17	15.43	0.56484
54	17	5.00	0.99778
55	17	19.91	0.27883
56	17	19.69	0.29032
57	17	21.30	0.21311
58	17	13.55	0.69857
59	17	16.40	0.49569
60	17	11.07	0.85315
61	17	22.66	0.16051

62	17	20.54	0.24753
63	17	18.40	0.36424
64	17	16.37	0.49757
65	17	15.34	0.57071
66	17	8.93	0.94230
67	17	15.32	0.57263
68	17	21.37	0.21013
69	17	15.66	0.54803
70	17	7.33	0.97892
71	17	16.69	0.47536
72	17	18.76	0.34277
73	17	14.93	0.60080
74	17	15.78	0.53959
75	17	18.98	0.32987
76	17	11.73	0.81613
77	17	16.18	0.51133
78	17	14.22	0.65173
79	17	14.19	0.65361
80	17	11.08	0.85228
81	17	14.45	0.63537
82	17	15.46	0.56259
83	17	16.63	0.47980
84	17	14.48	0.63296
85	17	11.16	0.84802
86	17	19.24	0.31503
87	17	5.57	0.99563
88	17	15.76	0.54058
89	17	16.84	0.46495
90	17	21.85	0.19070
91	17	18.80	0.34007
92	17	21.27	0.21425
93	17	18.23	0.37452
94	17	23.53	0.13289
95	17	9.58	0.92034
96	17	18.32	0.36920
97	17	24.08	0.11722
98	17	15.92	0.52954
99	17	17.03	0.45267
100	17	22.39	0.17006
Combined P-value for all tests (Using KS method)			0.37791

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	54.49	0.30769
2	50	36.96	0.91475
3	50	49.73	0.48428

4	50	41.07	0.81184
5	50	45.10	0.66995
6	50	58.31	0.19622
7	50	46.16	0.62823
8	50	48.29	0.54206
9	50	69.80	0.03357
10	50	47.32	0.58140
11	50	64.32	0.08381
12	50	39.73	0.85057
13	50	44.21	0.70389
14	50	33.98	0.95960
15	50	52.41	0.38061
16	50	37.89	0.89563
17	50	50.17	0.46649
18	50	44.75	0.68360
19	50	52.26	0.38636
20	50	46.13	0.62936
21	50	75.67	0.01102
22	50	67.93	0.04653
23	50	73.97	0.01543
24	50	52.78	0.36704
25	50	36.23	0.92794
26	50	46.63	0.60934
27	50	33.96	0.95986
28	50	42.63	0.76080
29	50	60.29	0.15120
30	50	40.47	0.82994
31	50	51.43	0.41758
32	50	52.29	0.38515
33	50	45.62	0.64974
34	50	58.59	0.18954
35	50	55.05	0.28948
36	50	50.90	0.43791
37	50	50.98	0.43472
38	50	42.70	0.75858
39	50	40.01	0.84283
40	50	37.31	0.90790
41	50	46.07	0.63181
42	50	50.31	0.46103
43	50	51.86	0.40125
44	50	46.75	0.60446
45	50	60.46	0.14759
46	50	59.66	0.16458
47	50	48.37	0.53916
48	50	37.81	0.89749
49	50	48.20	0.54588
50	50	50.89	0.43842
51	50	57.39	0.22016
52	50	60.80	0.14096

53	50	40.18	0.83817
54	50	48.20	0.54578
55	50	65.56	0.06893
56	50	56.23	0.25312
57	50	54.76	0.29874
58	50	60.80	0.14083
59	50	43.34	0.73573
60	50	42.98	0.74854
61	50	45.58	0.65115
62	50	39.01	0.86934
63	50	47.82	0.56124
64	50	37.81	0.89747
65	50	43.93	0.71416
66	50	45.47	0.65558
67	50	34.99	0.94691
68	50	58.26	0.19758
69	50	32.22	0.97608
70	50	51.34	0.42111
71	50	48.55	0.53167
72	50	49.66	0.48706
73	50	58.69	0.18692
74	50	56.80	0.23656
75	50	52.24	0.38706
76	50	50.30	0.46155
77	50	39.31	0.86187
78	50	34.81	0.94934
79	50	65.64	0.06802
80	50	46.65	0.60874
81	50	44.25	0.70224
82	50	35.33	0.94215
83	50	47.92	0.55719
84	50	44.30	0.70040
85	50	55.58	0.27282
86	50	73.61	0.01654
87	50	43.14	0.74308
88	50	56.19	0.25435
89	50	50.57	0.45074
90	50	62.61	0.10872
91	50	52.95	0.36101
92	50	58.86	0.18294
93	50	48.79	0.52204
94	50	62.03	0.11827
95	50	55.16	0.28588
96	50	54.37	0.31152
97	50	59.34	0.17166
98	50	45.74	0.64486
99	50	47.09	0.59080
100	50	58.47	0.19232
Combined P-value for all tests			0.99525

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	10.71	0.55411
2	12	3.32	0.99279
3	12	4.52	0.97223
4	12	6.48	0.88994
5	12	14.55	0.26671
6	12	4.65	0.96872
7	12	5.53	0.93798
8	12	2.85	0.99650
9	12	18.57	0.09939
10	12	5.90	0.92110
11	12	13.55	0.33018
12	12	1.51	0.99987
13	12	6.55	0.88563
14	12	12.55	0.40258
15	12	28.13	0.00530
16	12	7.71	0.80706
17	12	8.14	0.77391
18	12	16.24	0.18032
19	12	11.69	0.47084
20	12	14.06	0.29720
21	12	9.91	0.62383
22	12	10.72	0.55305
23	12	11.83	0.45934
24	12	6.54	0.88627
25	12	13.40	0.34094
26	12	18.22	0.10927
27	12	5.77	0.92735
28	12	17.58	0.12904
29	12	13.92	0.30603
30	12	24.62	0.01674
31	12	14.88	0.24795
32	12	12.52	0.40482
33	12	12.78	0.38507
34	12	6.97	0.85969
35	12	23.00	0.02776
36	12	9.58	0.65272
37	12	7.93	0.79068

38	12	20.18	0.06373
39	12	16.49	0.16960
40	12	10.67	0.55772
41	12	6.59	0.88371
42	12	15.51	0.21490
43	12	11.94	0.45015
44	12	15.53	0.21362
45	12	5.53	0.93790
46	12	4.65	0.96873
47	12	26.88	0.00804
48	12	10.39	0.58220
49	12	8.86	0.71443
50	12	9.83	0.63111
51	12	12.77	0.38578
52	12	4.47	0.97344
53	12	9.76	0.63738
54	12	7.99	0.78587
55	12	12.68	0.39253
56	12	10.61	0.56252
57	12	15.01	0.24076
58	12	13.86	0.30961
59	12	7.93	0.79060
60	12	7.17	0.84604
61	12	5.01	0.95773
62	12	13.17	0.35690
63	12	10.68	0.55619
64	12	23.98	0.02047
65	12	10.96	0.53274
66	12	9.27	0.67958
67	12	8.67	0.73089
68	12	19.09	0.08644
69	12	13.54	0.33100
70	12	9.86	0.62782
71	12	10.53	0.56988
72	12	8.43	0.75075
73	12	10.50	0.57255
74	12	8.40	0.75337
75	12	9.05	0.69889
76	12	12.59	0.39948
77	12	7.83	0.79821
78	12	7.88	0.79475
79	12	13.75	0.31671
80	12	5.00	0.95799
81	12	12.45	0.41014
82	12	14.24	0.28548
83	12	17.20	0.14237
84	12	14.79	0.25289
85	12	14.14	0.29203
86	12	11.13	0.51816

87	12	5.01	0.95779
88	12	5.45	0.94118
89	12	13.14	0.35899
90	12	14.49	0.27062
91	12	11.17	0.51457
92	12	8.21	0.76828
93	12	14.22	0.28695
94	12	13.20	0.35478
95	12	19.12	0.08578
96	12	10.79	0.54734
97	12	4.95	0.95963
98	12	26.42	0.00936
99	12	11.50	0.48693
100	12	11.69	0.47088
Combined P-value for all tests (Using KS method)			0.46825

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	6.32	0.89914
2	12	11.20	0.51221
3	12	11.97	0.44837
4	12	4.49	0.97295
5	12	10.77	0.54867
6	12	15.88	0.19685
7	12	7.48	0.82438
8	12	9.44	0.66528
9	12	22.50	0.03224
10	12	16.08	0.18775
11	12	13.41	0.34021
12	12	9.36	0.67223
13	12	9.92	0.62255
14	12	23.59	0.02313
15	12	14.88	0.24820
16	12	2.23	0.99896
17	12	8.26	0.76419
18	12	5.32	0.94639
19	12	19.90	0.06907
20	12	19.06	0.08720
21	12	15.58	0.21140
22	12	20.49	0.05839
23	12	9.96	0.61911
24	12	16.80	0.15746
25	12	18.09	0.11297
26	12	14.47	0.27145
27	12	11.92	0.45232
28	12	8.32	0.75999
29	12	8.57	0.73957
30	12	5.04	0.95664
31	12	23.97	0.02056
32	12	9.70	0.64203

33	12	7.57	0.81808
34	12	9.64	0.64709
35	12	8.76	0.72328
36	12	8.83	0.71719
37	12	16.85	0.15524
38	12	11.10	0.52053
39	12	6.43	0.89290
40	12	11.22	0.50993
41	12	18.24	0.10872
42	12	10.01	0.61517
43	12	9.54	0.65646
44	12	15.87	0.19746
45	12	12.37	0.41673
46	12	5.80	0.92577
47	12	9.53	0.65696
48	12	9.56	0.65444
49	12	9.97	0.61822
50	12	14.59	0.26442
51	12	11.13	0.51791
52	12	7.31	0.83621
53	12	15.83	0.19914
54	12	7.81	0.79972
55	12	20.64	0.05598
56	12	10.31	0.58917
57	12	8.98	0.70480
58	12	10.66	0.55831
59	12	13.90	0.30725
60	12	14.37	0.27784
61	12	7.64	0.81269
62	12	11.83	0.45939
63	12	4.28	0.97784
64	12	13.31	0.34698
65	12	2.11	0.99922
66	12	9.86	0.62848
67	12	19.85	0.06989
68	12	9.67	0.64514
69	12	17.70	0.12520
70	12	10.20	0.59858
71	12	12.81	0.38302
72	12	10.85	0.54210
73	12	12.79	0.38459
74	12	9.16	0.68940
75	12	17.79	0.12235
76	12	13.10	0.36198
77	12	22.53	0.03196
78	12	10.80	0.54650
79	12	9.49	0.66023
80	12	13.13	0.35932
81	12	4.73	0.96651
82	12	10.23	0.59541
83	12	20.09	0.06542
84	12	7.63	0.81305
85	12	15.30	0.22534
86	12	9.42	0.66711
87	12	18.77	0.09426
88	12	9.53	0.65671

89	12	9.55	0.65507
90	12	21.95	0.03807
91	12	13.17	0.35671
92	12	16.48	0.17004
93	12	15.70	0.20529
94	12	9.76	0.63721
95	12	10.76	0.54996
96	12	12.68	0.39300
97	12	10.58	0.56546
98	12	21.02	0.05003
99	12	4.71	0.96707
100	12	11.88	0.45555
Combined P-value for all tests (Using KS method)			0.56403

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)	0.86812	1.00000
Opening Score (Dealer)	0.37791	1.00000
Dealer's Final Score	0.99525	1.00000
Player Cards Rank	0.46825	1.00000
Dealer Cards Rank	0.56403	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.

Signed:



Divya Bhargava
Project Manager
iTech Labs Australia
Date: 12 June 2024

Signed:



Alvin Rizaldi
Chief Executive Officer
iTech Labs Australia
Date: 12 June 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.