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28 November 2025

Suresh Yellayi  
Entain Operations Limited  
Suite 6, Atlantic Suites  
Europort Avenue, Gibraltar

Re: Mathematical Analysis of *Blackjack*

File Number: MA-00-GSV-25-06

Dear Mr. Yellayi,

As per Entain Operations Limited's request, please find **Gaming Laboratories International, LLC's (GLI)** mathematical analysis of the following Blackjack:

1. *Blackjack*

**This report only verifies the mathematical aspects of these games and DOES NOT offer an opinion as to whether or not these games are currently authorized for use in any jurisdiction.**

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### Mathematical Analysis

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**Gaming Laboratories International, LLC (GLI)** was requested by Entain Operations Limited to independently calculate the expected payback for the aforementioned games and confirm that the returns are within the requirements. On the following page, please find a table containing the summary of our results.

### 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. The dealer's final hand value is based on the fixed rules of the game. The player's final hand value is dependent on the player's strategy choice, so it has no theoretical basis for comparison.

The null hypothesis for the chi-square test is that the observed frequencies of each type of hand match 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	14.96	0.59846
2	17	20.93	0.22954
3	17	20.87	0.23207
4	17	11.52	0.82814
5	17	14.75	0.61338
6	17	22.57	0.16380
7	17	12.33	0.77961
8	17	11.85	0.80932
9	17	22.23	0.17600
10	17	11.50	0.82941
11	17	15.02	0.59389
12	17	15.00	0.59578

Test No.	DOF	ChiSqr	P-Value
13	17	41.96	0.00068
14	17	12.83	0.74763
15	17	17.07	0.44970
16	17	24.82	0.09876
17	17	38.63	0.00201
18	17	12.28	0.78309
19	17	10.69	0.87203
20	17	15.17	0.58290
21	17	14.74	0.61445
22	17	19.29	0.31190
23	17	22.39	0.17000
24	17	11.44	0.83261
25	17	9.39	0.92724
26	17	8.09	0.96455
27	17	26.93	0.05903
28	17	13.54	0.69906
29	17	15.46	0.56263
30	17	16.68	0.47634
31	17	26.17	0.07133
32	17	13.33	0.71364
33	17	13.49	0.70266
34	17	20.31	0.25849
35	17	12.48	0.77003

Test No.	DOF	ChiSqr	P-Value
36	17	19.69	0.29028
37	17	9.13	0.93624
38	17	20.63	0.24307
39	17	22.89	0.15297
40	17	7.81	0.97050
41	17	11.22	0.84474
42	17	15.30	0.57385
43	17	13.27	0.71799
44	17	23.19	0.14320
45	17	15.44	0.56365
46	17	18.97	0.33008
47	17	9.69	0.91606
48	17	13.49	0.70310
49	17	14.02	0.66553
50	17	19.93	0.27767
51	17	8.72	0.94854
52	17	17.36	0.43029
53	17	24.61	0.10390
54	17	23.11	0.14566
55	17	17.78	0.40281
56	17	14.63	0.62214
57	17	14.05	0.66360
58	17	18.85	0.33745

Test No.	DOF	ChiSqr	P-Value
59	17	11.97	0.80221
60	17	15.95	0.52742
61	17	19.12	0.32144
62	17	14.27	0.64813
63	17	13.21	0.72208
64	17	18.00	0.38876
65	17	19.00	0.32871
66	17	23.85	0.12365
67	17	17.10	0.44767
68	17	12.39	0.77572
69	17	19.59	0.29584
70	17	12.47	0.77057
71	17	20.02	0.27323
72	17	25.46	0.08488
73	17	10.17	0.89617
74	17	20.49	0.24981
75	17	16.69	0.47537
76	17	14.01	0.66650
77	17	10.81	0.86649
78	17	17.38	0.42913
79	17	11.55	0.82657
80	17	8.74	0.94804
81	17	13.17	0.72465

Test No.	DOF	ChiSqr	P-Value
82	17	16.30	0.50250
83	17	11.51	0.82877
84	17	17.02	0.45269
85	17	17.07	0.44991
86	17	19.10	0.32285
87	17	19.22	0.31624
88	17	23.21	0.14254
89	17	9.67	0.91680
90	17	16.37	0.49808
91	17	13.02	0.73454
92	17	27.03	0.05758
93	17	19.82	0.28376
94	17	13.98	0.66828
95	17	18.79	0.34094
96	17	17.26	0.43666
97	17	17.71	0.40707
98	17	22.05	0.18272
99	17	18.54	0.35585
100	17	16.69	0.47527
Combined P-Value for 100 tests (Using KS method)			0.86006

*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	15.98	0.52532
2	17	16.14	0.51367
3	17	29.92	0.02694
4	17	24.20	0.11417
5	17	22.12	0.17998
6	17	16.52	0.48744
7	17	24.64	0.10296
8	17	19.17	0.31899
9	17	23.28	0.14033
10	17	18.16	0.37859
11	17	11.16	0.84806
12	17	19.09	0.32326
13	17	16.55	0.48544
14	17	12.92	0.74142
15	17	19.31	0.31120
16	17	23.53	0.13269
17	17	10.12	0.89847
18	17	15.71	0.54426
19	17	19.29	0.31189
20	17	15.04	0.59288
21	17	8.08	0.96480
22	17	23.62	0.13023
23	17	17.18	0.44199

Test No.	DOF	ChiSqr	P-Value
24	17	15.26	0.57704
25	17	20.60	0.24460
26	17	20.03	0.27291
27	17	17.56	0.41725
28	17	19.34	0.30911
29	17	11.23	0.84458
30	17	27.81	0.04723
31	17	9.48	0.92399
32	17	9.09	0.93748
33	17	8.43	0.95652
34	17	21.28	0.21392
35	17	19.68	0.29101
36	17	20.48	0.25026
37	17	13.78	0.68284
38	17	15.45	0.56281
39	17	12.46	0.77137
40	17	11.80	0.81218
41	17	15.11	0.58788
42	17	16.67	0.47720
43	17	23.83	0.12410
44	17	21.38	0.20968
45	17	10.72	0.87095
46	17	17.22	0.43944



Test No.	DOF	ChiSqr	P-Value
47	17	12.01	0.79961
48	17	16.91	0.46032
49	17	15.02	0.59413
50	17	23.33	0.13888
51	17	17.96	0.39159
52	17	6.77	0.98633
53	17	21.58	0.20148
54	17	31.56	0.01705
55	17	15.78	0.53966
56	17	13.69	0.68884
57	17	26.05	0.07362
58	17	20.32	0.25812
59	17	10.76	0.86866
60	17	15.74	0.54225
61	17	7.75	0.97164
62	17	21.90	0.18874
63	17	14.12	0.65857
64	17	25.11	0.09236
65	17	20.94	0.22877
66	17	12.25	0.78457
67	17	13.13	0.72727
68	17	28.91	0.03534
69	17	12.13	0.79215

Test No.	DOF	ChiSqr	P-Value
70	17	16.38	0.49704
71	17	14.93	0.60026
72	17	16.41	0.49475
73	17	15.56	0.55551
74	17	21.76	0.19412
75	17	14.41	0.63816
76	17	15.09	0.58915
77	17	24.48	0.10708
78	17	9.09	0.93727
79	17	12.54	0.76641
80	17	9.16	0.93515
81	17	15.66	0.54779
82	17	22.39	0.17030
83	17	21.71	0.19612
84	17	17.27	0.43599
85	17	15.57	0.55459
86	17	12.58	0.76386
87	17	10.24	0.89335
88	17	17.99	0.38925
89	17	13.08	0.73076
90	17	16.14	0.51411
91	17	13.33	0.71397
92	17	19.64	0.29313

Test No.	DOF	ChiSqr	P-Value
93	17	16.71	0.47430
94	17	10.83	0.86530
95	17	25.72	0.07972
96	17	9.69	0.91617
97	17	6.80	0.98598
98	17	13.77	0.68360
99	17	9.95	0.90588
100	17	12.27	0.78381
Combined P-Value for 100 tests (Using KS method)			0.98168

*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	40.91	0.81670
2	50	37.34	0.90722
3	50	51.49	0.41529
4	50	58.80	0.18442
5	50	60.67	0.14347
6	50	79.49	0.00500
7	50	50.72	0.44486
8	50	55.73	0.26800
9	50	39.57	0.85493
10	50	51.99	0.39627
11	50	31.02	0.98389

Test No.	DOF	ChiSqr	P-Value
13	50	61.95	0.11965
14	50	56.83	0.23584
15	50	44.87	0.67880
16	50	36.98	0.91425
17	50	64.26	0.08465
18	50	31.62	0.98029
19	50	42.85	0.75337
20	50	47.43	0.57715
21	50	36.92	0.91545
22	50	47.99	0.55433
23	50	43.38	0.73441
24	50	49.49	0.49379
25	50	47.40	0.57828
26	50	90.39	0.00041
27	50	43.05	0.74637
28	50	31.73	0.97954
29	50	48.74	0.52411
30	50	34.35	0.95523
31	50	29.52	0.99070
32	50	53.54	0.34022
33	50	50.15	0.46737
34	50	42.90	0.75143
35	50	44.96	0.67545

Test No.	DOF	ChiSqr	P-Value
36	50	60.14	0.15421
37	50	53.52	0.34077
38	50	54.94	0.29295
39	50	56.18	0.25447
40	50	47.72	0.56554
41	50	46.84	0.60089
42	50	56.89	0.23403
43	50	73.32	0.01749
44	50	50.26	0.46293
45	50	58.99	0.17992
46	50	42.90	0.75149
47	50	49.48	0.49435
48	50	39.85	0.84740
49	50	55.26	0.28280
50	50	46.72	0.60578
51	50	46.83	0.60133
52	50	46.81	0.60212
53	50	50.37	0.45882
54	50	33.11	0.96856
55	50	35.06	0.94602
56	50	45.64	0.64899
57	50	41.76	0.79018
58	50	39.33	0.86122

Test No.	DOF	ChiSqr	P-Value
59	50	73.72	0.01619
60	50	38.67	0.87770
61	50	39.44	0.85836
62	50	36.25	0.92755
63	50	42.79	0.75528
64	50	42.83	0.75391
65	50	40.65	0.82453
66	50	33.74	0.96220
67	50	56.83	0.23577
68	50	52.18	0.38914
69	50	45.18	0.66686
70	50	57.73	0.21112
71	50	56.79	0.23687
72	50	35.64	0.93753
73	50	51.43	0.41762
74	50	56.60	0.24233
75	50	47.19	0.58694
76	50	54.55	0.30556
77	50	47.96	0.55571
78	50	39.62	0.85362
79	50	47.24	0.58478
80	50	51.01	0.43389
81	50	53.16	0.35359

Test No.	DOF	ChiSqr	P-Value
82	50	39.28	0.86251
83	50	45.24	0.66445
84	50	45.19	0.66662
85	50	46.11	0.63018
86	50	57.34	0.22158
87	50	53.28	0.34937
88	50	47.38	0.57898
89	50	77.18	0.00811
90	50	74.40	0.01419
91	50	49.56	0.49083
92	50	54.33	0.31315
93	50	47.86	0.55968
94	50	36.24	0.92766
95	50	62.97	0.10293
96	50	52.00	0.39582
97	50	42.94	0.75010
98	50	50.77	0.44321
99	50	40.81	0.81989
100	50	35.37	0.94161
Combined P-Value for 100 tests (Using KS method)			0.32061

**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	6.49	0.88914
2	12	12.91	0.37591
3	12	23.27	0.02556
4	12	5.14	0.95311
5	12	15.55	0.21292
6	12	9.80	0.63337
7	12	6.81	0.87009
8	12	13.85	0.31038
9	12	9.10	0.69396
10	12	5.17	0.95198
11	12	9.27	0.67987
12	12	12.17	0.43232
13	12	18.75	0.09482
14	12	13.11	0.36087
15	12	8.81	0.71878
16	12	15.54	0.21307



Test No.	DOF	ChiSqr	P-Value
17	12	8.65	0.73291
18	12	11.88	0.45549
19	12	14.28	0.28333
20	12	8.98	0.70456
21	12	14.52	0.26863
22	12	14.00	0.30082
23	12	13.75	0.31716
24	12	16.04	0.18935
25	12	13.04	0.36631
26	12	7.91	0.79241
27	12	9.64	0.64786
28	12	9.02	0.70092
29	12	9.32	0.67504
30	12	12.91	0.37573
31	12	16.66	0.16297
32	12	21.27	0.04650
33	12	9.15	0.69026
34	12	15.89	0.19634
35	12	10.22	0.59683
36	12	11.93	0.45157
37	12	7.87	0.79519
38	12	18.04	0.11436
39	12	9.73	0.63920
40	12	7.27	0.83907

Test No.	DOF	ChiSqr	P-Value
41	12	6.99	0.85829
42	12	12.74	0.38848
43	12	11.82	0.46030
44	12	15.68	0.20618
45	12	11.68	0.47178
46	12	15.32	0.22463
47	12	5.08	0.95530
48	12	13.62	0.32569
49	12	13.88	0.30840
50	12	9.82	0.63218
51	12	15.82	0.19984
52	12	11.93	0.45104
53	12	22.57	0.03162
54	12	18.12	0.11210
55	12	9.53	0.65675
56	12	15.25	0.22817
57	12	4.15	0.98057
58	12	8.46	0.74809
59	12	12.48	0.40771
60	12	12.59	0.39954
61	12	16.97	0.15081
62	12	9.86	0.62825
63	12	26.67	0.00863
64	12	10.93	0.53478

Test No.	DOF	ChiSqr	P-Value
65	12	14.15	0.29128
66	12	13.80	0.31359
67	12	24.40	0.01793
68	12	15.53	0.21361
69	12	14.21	0.28755
70	12	17.94	0.11741
71	12	15.06	0.23829
72	12	7.68	0.80927
73	12	16.49	0.16996
74	12	17.08	0.14675
75	12	12.99	0.36987
76	12	8.59	0.73741
77	12	21.29	0.04632
78	12	12.97	0.37087
79	12	12.32	0.42058
80	12	5.11	0.95418
81	12	5.57	0.93616
82	12	6.73	0.87490
83	12	6.53	0.88728
84	12	10.93	0.53460
85	12	13.76	0.31659
86	12	13.90	0.30728
87	12	13.29	0.34824
88	12	12.91	0.37589

Test No.	DOF	ChiSqr	P-Value
89	12	4.96	0.95920
90	12	17.72	0.12461
91	12	12.81	0.38320
92	12	9.95	0.62033
93	12	19.95	0.06809
94	12	19.09	0.08640
95	12	9.64	0.64786
96	12	14.62	0.26271
97	12	9.35	0.67240
98	12	31.36	0.00174
99	12	15.19	0.23106
100	12	22.29	0.03436
Combined P-Value for 100 tests (Using KS method)			0.03641

**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	12.31	0.42083
2	12	15.81	0.20031
3	12	10.59	0.56407
4	12	14.66	0.26083
5	12	12.26	0.42520
6	12	13.55	0.33024
7	12	19.55	0.07619

Test No.	DOF	ChiSqr	P-Value
8	12	12.62	0.39723
9	12	13.26	0.35056
10	12	13.13	0.35996
11	12	18.17	0.11054
12	12	7.47	0.82494
13	12	14.17	0.29020
14	12	11.93	0.45152
15	12	19.11	0.08601
16	12	11.90	0.45412
17	12	7.30	0.83693
18	12	4.34	0.97645
19	12	7.26	0.84030
20	12	16.45	0.17129
21	12	18.16	0.11097
22	12	20.70	0.05492
23	12	5.48	0.93983
24	12	21.94	0.03817
25	12	19.52	0.07675
26	12	12.68	0.39272
27	12	7.56	0.81837
28	12	15.99	0.19171
29	12	18.92	0.09044
30	12	12.45	0.41062

Test No.	DOF	ChiSqr	P-Value
31	12	14.79	0.25331
32	12	8.61	0.73600
33	12	13.87	0.30890
34	12	12.40	0.41422
35	12	10.30	0.59004
36	12	16.31	0.17761
37	12	17.48	0.13236
38	12	6.26	0.90227
39	12	12.66	0.39416
40	12	7.69	0.80878
41	12	5.03	0.95713
42	12	5.91	0.92044
43	12	13.76	0.31661
44	12	11.15	0.51612
45	12	16.55	0.16713
46	12	8.69	0.72879
47	12	10.89	0.53799
48	12	4.53	0.97191
49	12	8.15	0.77361
50	12	7.03	0.85550
51	12	17.33	0.13751
52	12	12.64	0.39538
53	12	14.45	0.27302

Test No.	DOF	ChiSqr	P-Value
54	12	4.64	0.96898
55	12	17.81	0.12162
56	12	5.96	0.91825
57	12	16.85	0.15548
58	12	10.41	0.57967
59	12	12.52	0.40509
60	12	12.20	0.42959
61	12	16.50	0.16928
62	12	9.75	0.63773
63	12	6.52	0.88744
64	12	10.36	0.58459
65	12	4.65	0.96864
66	12	18.45	0.10280
67	12	9.04	0.69956
68	12	23.19	0.02618
69	12	11.04	0.52544
70	12	9.74	0.63844
71	12	5.53	0.93780
72	12	20.06	0.06601
73	12	8.27	0.76389
74	12	9.65	0.64683
75	12	23.32	0.02514
76	12	21.21	0.04743
77	12	8.12	0.77541

Test No.	DOF	ChiSqr	P-Value
78	12	9.91	0.62347
79	12	8.21	0.76854
80	12	8.49	0.74579
81	12	15.84	0.19859
82	12	16.35	0.17554
83	12	7.34	0.83463
84	12	17.07	0.14689
85	12	10.50	0.57233
86	12	12.09	0.43840
87	12	5.94	0.91903
88	12	16.42	0.17270
89	12	16.61	0.16475
90	12	8.59	0.73787
91	12	11.21	0.51101
92	12	8.00	0.78541
93	12	6.85	0.86740
94	12	18.26	0.10807
95	12	12.80	0.38365
96	12	10.16	0.60183
97	12	10.85	0.54222
98	12	9.02	0.70115
99	12	13.42	0.33916
100	12	14.65	0.26131
Combined P-Value for 100 tests (Using KS method)			0.53233



*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.

### 3. 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 Holm's method and producing a single Combined P-value.

The combined p-value produced using Holm's method is used as an indication of statistical randomness.

Combination of p-values using Holm's Method		
Test	P-Value	P-Adjusted
Opening Score (Player)	0.86006	1.00000
Opening Score (Dealer)	0.98168	1.00000
Dealer's Final Score	0.32061	1.00000
Player Cards Rank	0.03641	0.18204
Dealer Cards Rank	0.53233	1.00000
Combined P-Value using Holm's Method		0.18204

*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.

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## Conclusion

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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.

GLI has done limited sanity checks to verify the integrity of the game logs. GLI 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.

We conclude that the Random Number Generator (RNG) is working correctly.

Please note, the results contained herein are based on game design documentation provided to GLI by the manufacturer. It is the responsibility of the manufacturer to ensure that the gaming software performs in the same way as the documentation.

Please visit [Gaminglabs.com](http://Gaminglabs.com) to view the applicable Terms and Conditions and GLI Product Certification Scheme.

Should you have any questions or need any additional information, please feel free to contact our office.

Sincerely,

**GAMING LABORATORIES INTERNATIONAL, LLC**



Christine M. Gallo

Senior Vice President, Quality and Technical Compliance

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