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Mastering the Odds: Leveraging Probability and Statistics for Victory in Traditional Games

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Abstract. Traditional games like Roulette to Poker and Craps blend luck, skill, and psychology, captivating players through probability and statistics. This paper explores the strategic application of probability theory and statistical analysis to gain an advantage in traditional games of chance and skill. By focusing on canonical examples, this study demonstrates how mathematical principles underpin optimal decision-making. Through rigorous calculation of expected value (EV), odds assessment, variance management, and statistical inference, players can significantly improve their outcomes compared to relying on intuition or superstition. Detailed mathematical models, simulations, and real-game scenarios illustrate key concepts. Charts visualizing probability distributions, decision trees, and simulation results provide empirical support. While acknowledging inherent house edges in pure chance games and the role of psychology in adversarial games, this work establishes a framework for maximizing winning potential through quantitative reasoning. Responsible gaming practices are emphasized throughout.

Keywords: Probability Theory, Statistical Analysis, Expected Value (EV), Game Strategy

1. Introduction

Traditional games, deeply rooted in centuries of human culture, offer a captivating blend of luck, skill, and psychology. From the spinning wheels of Roulette to the shuffled cards of Poker and the rolling dice of Craps, these games are underpinned by a complex mathematical framework governed by probability and statistics. While chance undeniably influences outcomes, informed players can leverage mathematical principles to tilt the odds in their favor, transforming seemingly random events into strategic opportunities [1].

This paper investigates how core concepts like probability distributions, expected value, hypothesis testing, and statistical inference can be systematically applied to popular games like Roulette, Poker, and Craps. By analyzing these elements, the study aims to provide a robust quantitative framework for optimal decision-making. This approach enhances players' long-term winning potential and shifts the focus from merely descriptive probability to prescriptive strategies. Ultimately, this exploration empowers players to make informed choices and navigate the intricacies of chance and skill with greater confidence.

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2. Fundamental concepts: the mathematical arsenal

Before delving into specific games, it is essential to establish the essential mathematical tools for understanding and applying probability and statistics. Sample Space (S) is the set of all possible outcomes (e.g., S = {1, 2, 3, ..., 36} for a single number bet in Roulette, including '0' variations). Event (E) is a subset of the sample space (e.g., E = {Red Numbers}). Probability (P(E)) is the likelihood of event E occurring. For equally likely outcomes, $P(E) = |E|/|S|$. Odds, expressed as "A to B", indicate that every B units wagered. A units are won in profit if successful. Odds relate to probability: Odds against $E = [1 - P(E)] : P\left(\bar{E}\right)$. Expected value (EV) represents the average amount a player can expect to win or lose per bet in the long run [2].

$$EV = \sum[P(Outcome_i) \times Payoff(Outcome_i)] \tag{1}$$

A positive EV (+EV) indicates a profitable bet over time; a negative EV (-EV) indicates a losing proposition. Casinos design games to ensure an overall house edge (negative EV for players) [3].

Variance and standard deviation measure the spread or volatility of outcomes around the EV. High variance means larger potential swings (big wins or big losses) in the short term, with positive EV indicating profitability and negative EV indicating a losing proposition [4-5].

$$Variance\left(\sigma^2\right) = \sum[P\left(Outcome_i\right) \times \left(Payoff\left(Outcome_i\right) - EV\right)^2] \tag{2}$$

$$Standard\ Deviation\left(\sigma\right) = \sqrt{Variance} = \sqrt{\sigma^2} \tag{3}$$

Conditional probability and Bayes' Theorem are essential for games involving incomplete information (like Poker), allowing players to update probabilities based on new evidence. P(A|B) is the probability of event A occurring given that event B has occurred [6-8].

$$P\left(A\middle|B\right) = \frac{P(AB)}{P(B)} \tag{4}$$

Probability distributions, like discrete uniform, binomial, and hypergeometric, describe the likelihood of different outcomes in various scenarios. The discrete uniform distribution treats all outcomes equally (e.g., a fair die roll or a single number win in Roulette). The binomial distribution calculates the number of successes in a fixed number of independent trials (e.g., heads in coin flips or specific number hits in Roulette). The hypergeometric distribution applies to drawing successes from a finite population without replacement (e.g., specific starting hands in Poker) [9].

The Law of Large Numbers ensures that as trials increase, the sample mean converges to the theoretical expected value, while the Central Limit Theorem explains the normal distribution of sample means, aiding in confidence interval estimation.

3. Case study 1: Roulette - navigating the wheel of chance

Roulette exemplifies a game of pure chance, showcasing key probability concepts and the house edge. European Roulette features a single zero, resulting in 37 pockets with a probability of 1/37 (approximately 2.703%) for a single number bet. In contrast, American Roulette has 38 pockets (including a double zero), reducing the probability to 1/38 (about 2.632%) [10]. When calculating

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the house edge through expected value (EV) analysis, one must consider a $1 bet on a single number in European Roulette; the probability of winning is 1/37, with a payoff of $35, which includes winning $35 plus the return of the original $1 stake. Conversely, the probability of losing is 36/37, with a payoff of -$1, signifying the loss of the initial stake.

$$\mathrm{EV} = \tfrac{1}{37} \times 35 + \tfrac{36}{37} \times \left(-1\right) \approx -0.02703 \tag{5}$$

The EV is negative, indicating a loss of approximately 2.703 cents per $1 wagered. This is the House Edge.

In European Roulette, even money bets (Red/Black, , such as red/black, odd/even, or high/low, have a probability of winning at 18/37, approximately 0.4865, with a payoff of $1, which includes winning $1 plus the return of the $1 stake, carrying the same house edge.

$$\mathrm{EV} = \tfrac{18}{37} \times 1 + \tfrac{19}{37} \times \left(-1\right) \approx -0.02703 \tag{6}$$

Similarly, a dozen bet covering numbers 1 through 12 has a winning probability of 12/37, with a payoff of $2, which includes winning $2 plus the return of the $1 stake.

$$\mathrm{EV} = \tfrac{12}{37} \times 2 + \tfrac{25}{37} \times \left(-1\right) \approx -0.02703 \tag{7}$$

It is concluded that all bets on a single-zero wheel carry the same house edge of 1/37 (≈2.703%). The house edge on a double-zero wheel is higher at 2/38 (≈5.263%). Visualizations such as Figure 1 and Figure 2 further illustrate the uniformity of probabilities and the impact of additional zeros on betting outcomes.

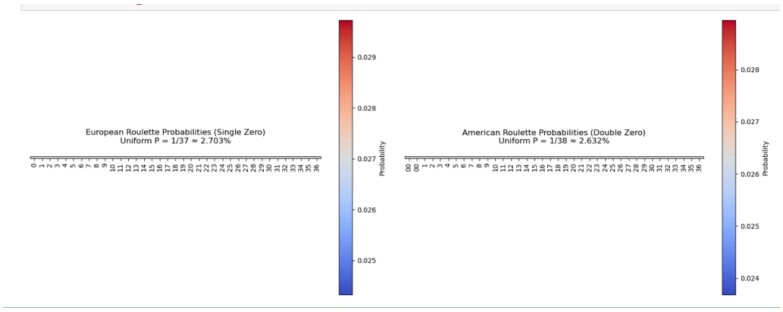


Figure 1. Heatmap of a Roulette wheel showing the true probability (1/37 or 1/38) for each number, visually reinforcing uniformity and the presence of zero(s)

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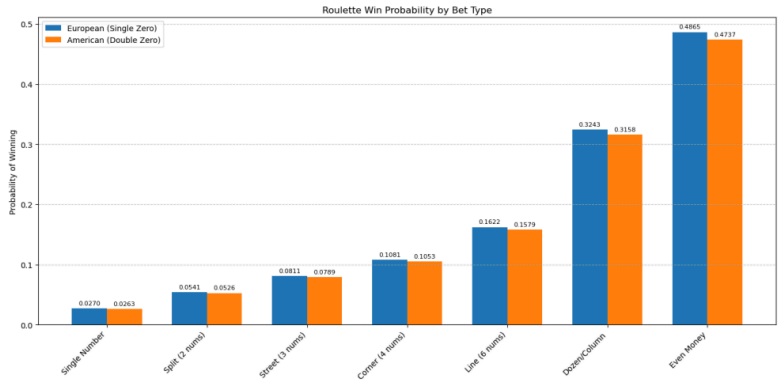


Figure 2. Bar chart comparing the probability of winning various bet types (single number, split, street, corner, line, dozen/column, even money) on European vs. American wheels, highlighting the impact of the extra '00'

Probability theory unequivocally shows that no betting system (Martingale, Labouchere, D'Alembert) can overcome the negative EV. These systems alter bet sizing based on previous outcomes but cannot change the fundamental odds of each independent spin. The LLN guarantees the house edge will prevail over time. Bankroll management and choosing the single-zero wheel are the only rational "strategies."

4. Case study 2: Poker (Texas Hold'em) - skill, psychology, and inference

Poker is a game of incomplete information and skill, where probability and statistics are used dynamically to estimate hand strength, predict opponents' holdings (ranges), and calculate the profitability of actions (betting, calling, folding, raising).

The pre-flop stage involves starting hand selection, which can be analyzed using the hypergeometric distribution [11]. For instance, P(Any Specific Pocket Pair, e.g., AA) = $\frac{4}{52} \times \frac{3}{51} = \frac{1}{221} \approx 0.00452$ (0.452%). P(Any Pocket Pair) = 13×P(AA) = $13 \times \frac{1}{221} = \frac{13}{221} \approx 0.0588$ (5.88%). Suited connectors, such as 7♥8♥, have a probability of about 3.62%. Table 1 enumerates the probability and percentage of various hand groups

Table 1. Probability and percentage of various hand groups

Hand Group	Example Hands	Combinations	Probability	Percentage
Any Pocket Pair	AA, 77, 22	78	78/1326	5.88%
Specific Pocket Pair	AA only	6	6/1326	0.45%
Suited Connectors	78s, JTs, 45s	48	48/1326	3.62%
Suited Aces	AKs, AQs, A5s	48	48/1326	3.62%
Offsuit Broadway	AKo, KQo, QJo	120	120/1326	9.05%
Any Ace-X Suited	A2s-AKs	48	48/1326	3.62%
Connected Broadways	KQs, QJs, JTs	24	24/1326	1.81%
Premium Pairs (JJ+)	AA, KK, QQ, JJ	24	24/1326	1.81%

Post-flop, hand equity and pot odds become crucial. Hand equity is the probability your hand will win against an opponent's perceived range by the river, calculated using combinatorics or simulation software. For example, holding A♣K♣ on a flop of Q♣7♣2♦ with a nut flush draw (9 outs),

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assuming the opponent has at least top pair (Qx), the approximate equity is about 35%. Using combinations of unseen cards or simulation (actual ≈ 34.97% against QJ) is more accurate.

Pot odds, the ratio of the current pot size to the cost of a contemplated call, are also essential; for instance, if the pot is $100 and an opponent bets $50, the pot odds are 3:1. A call is mathematically profitable if the equity is greater than the cost to call divided by the pot size after the call. The expected value (EV) of actions is central to poker strategy, with EV calculated for folding, calling, or raising based on assumptions about opponent actions and hand ranges. In a simplified river scenario with a $200 pot and an opponent betting $100 all-in, if there is a 30% chance to win, calling results in a +$20 EV, making it the +EV play. Implied odds and reverse implied odds adjust pot odds calculations based on expected future winnings (implied odds - good for draws) or losses (reverse implied odds - bad when drawing to second-best hands).

Observing betting patterns, timing tells, and using HUDs (Heads-Up Displays) to gather statistics (e.g., VPIP - Voluntarily Put $ In Pot, PFR - Pre-Flop Raise, Aggression Frequency) allows players to build probabilistic models of opponents' strategies and exploit deviations from optimal play. Visual aids in Figure 3 and Figure 4 illustrate the probability of different outcomes and the EV of specific decisions.

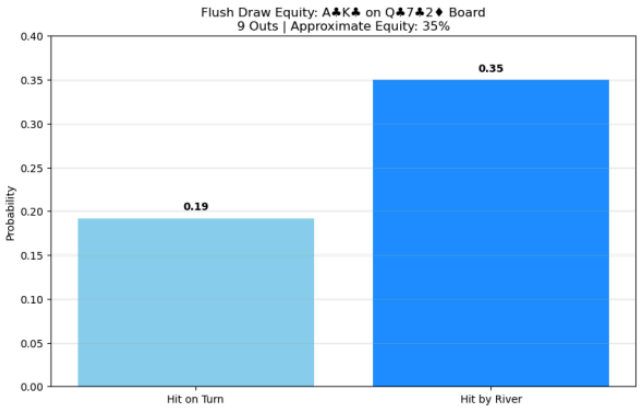


Figure 3. Equity distribution chart: shows the probability (equity) of player A's hand (e.g., A♣K♣) against player B's range (e.g., {QQ, KK, AQ}) on a given board (Q♣7♣2♦)

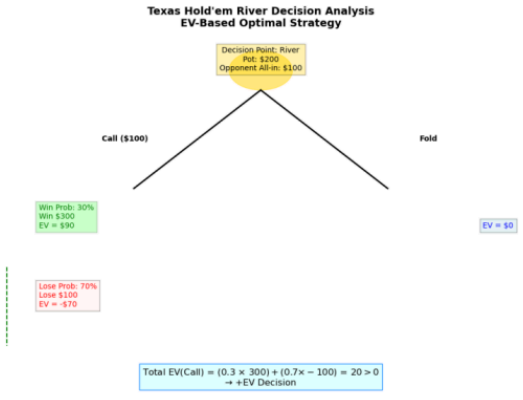


Figure 4. Decision tree: illustrating the EV calculation for a specific pre-flop or post-flop decision point, incorporating probabilities of opponent actions and outcomes

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Success in poker hinges on consistently identifying and executing +EV decisions based on probability calculations (hand equity, pot odds), statistical analysis of opponents, and sound bankroll management to withstand variance. Bluffing and deception are effective because they manipulate opponents' probability assessments.

5. Case study 3: Craps - dice dynamics and betting choices

Craps involves rolling two dice, creating a complex probability landscape [12]. Understanding the distributions and associated bets is key. The sum of the two dice, ranging from 2 to 12, follows a probability distribution, as shown in Figure 5.

Number of outcomes: $6 \times 6 = 36$.

$P(S=7) = 6/36 = 1/6 \approx 0.1667$ (Most likely sum).

$P(S=2) = P(S=12) = 1/36 \approx 0.0278$.

$P(S=6) = P(S=8) = 5/36 \approx 0.1389$.

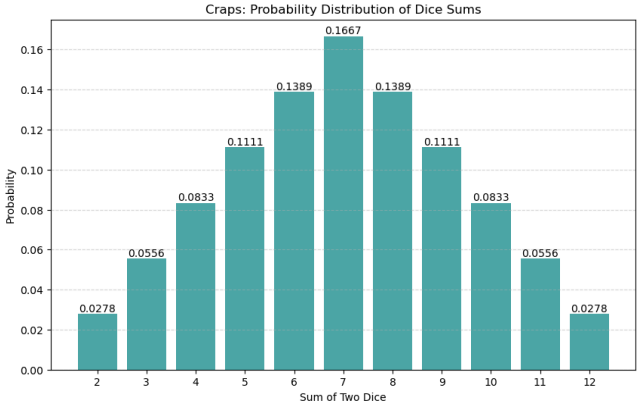


Figure 5. Bar chart showing the probability distribution of the sum of two dice (2 to 12)

In Craps, different bets come with varying house edges, which are critical to consider. The Pass Line Bet, a fundamental bet in Craps, offers one of the best odds in the casino with a house edge of approximately 1.41%. Conversely, the Don't Pass Line Bet has a slightly lower house edge of about 1.36%. Place Bets, such as betting on the numbers 6 or 8, have a house edge of approximately 1.52%, while Proposition Bets like Any 7 have a significantly higher house edge of about 16.67%. Table 2 presents a comprehensive list of common Craps bets, detailing their true odds, casino payouts, probability of winning, and calculated house edge, which is essential for making strategic decisions in Table 2.

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Table 2. Comprehensive list of common Craps bets (pass line, don't pass, come, don't come, place 4/10, place 5/9, place 6/8, field, any 7, hardways) with their true odds, casino payoff, probability of win, and calculated house edge

Bet Type	True Odds	Casino Pays	P(Win)	House Edge
Pass Line	251:244	1:1	49.29%	1.41%
Don't Pass	976:949	1:1	47.93%	1.36%
Place 6/8	6:5	7:6	45.45%	1.52%
Place 5/9	3:2	7:5	40.00%	4.00%
Place 4/10	2:1	9:5	33.33%	6.67%
Any 7	5:1	4:1	16.67%	16.67%
Hard 6	10:1	9:1	9.09%	9.09%

The strategy implications for Craps are clear: players should opt for low house edge bets (Pass Line, Don't Pass, Come, Don't Come with odds) and avoid high house edge proposition bets. Taking or laying full "Odds" behind a Pass/Don't Pass or Come/Don't Come bet (after a point is established) is crucial, as these bets have zero house edge, reducing the game's overall disadvantage.

6. Advanced applications & limitations

Carlo Simulation, which is extensively utilized for complex probability estimations where deriving analytical solutions is challenging. This method is particularly helpful in scenarios such as calculating multi-way poker equity with complex hand ranges and boards, or simulating millions of Craps or Roulette sessions to model bankroll risk. Card counting in Blackjack exemplifies how statistical tracking of high versus low cards remaining can alter probability assessments, providing a player advantage when the count is high, and influencing bet sizing through the Kelly Criterion. The Kelly Criterion itself is an optimal bankroll management strategy designed for maximizing long-term growth when a player possesses an edge, calculated as the fraction of the bankroll to bet, equal to (bp - q) / b, where b represents the net odds received and p is the probability of winning, with q being the probability of losing (q=1-p), requiring precise edge estimation.

However, there are limitations and caveats to consider. The house edge in casino games represents a mathematical disadvantage in casino games is insurmountable in the long run without an edge (like card counting). Variance and short-term luck mean that EV is a long-term concept. Short-term results can deviate wildly due to variance. Bankroll must withstand downswings. Imperfect Information (Poker) necessities estimating opponent ranges and actions, involving uncertainty. Psychological factors , with psychological factors like bluffs and tells adding further complexity. The assumption of independence versus dependence is critical for many calculations; assuming that dice rolls, card shuffles, or wheel spins are independent events is standard, although non-random shuffling or biased wheels/dice, while rare, can violate this assumption. Responsible gaming is essential; while mathematics can inform strategy, it cannot guarantee wins. Gambling should be approached as entertainment with strict loss limits.

7. Conclusion

Probability theory and statistical analysis provide a powerful, rational framework for understanding and mastering traditional games. By calculating expected values, assessing true odds versus payout

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odds, managing variance, and employing statistical inference (especially in games like Poker), players can make significantly more informed decisions. This paper demonstrated this through detailed analyses of Roulette (highlighting the fixed house edge), Poker (showcasing dynamic EV calculation and range analysis), and Craps (illustrating dice probabilities and bet selection). Charts and formulas provided concrete evidence for strategic choices. While chance remains a fundamental element, and the house edge is a persistent reality in casino games, a deep understanding of the underlying mathematics transforms gameplay from reliance on luck to the execution of statistically sound strategy. The key to success lies in consistently identifying +EV opportunities, managing bankroll effectively to survive variance, and recognizing the inherent limitations of mathematical prediction in the face of randomness and incomplete information. Ultimately, these tools empower players to maximize their winning potential based on reason rather than superstition.

References

[1] Ethier, S. N. (2010). The Doctrine of Chances: Probabilistic Aspects of Gambling. Springer.
[2] Hannum, R. C., & Cabot, A. N. (2005). Practical Casino Math (2nd ed.). Institute for the Study of Gambling and Commercial Gaming.
[3] Chen, B., & Ankenman, J. (2006). The Mathematics of Poker. ConJelCo LLC.
[4] Epstein, R. A. (2009). The Theory of Gambling and Statistical Logic (2nd ed.). Academic Press.
[5] Bollman, M. (2014). Mathematics in Games, Sports, and Gambling: The Games People Play. CRC Press.
[6] Shackleford, M. (2023). Wizard of Odds. https: //wizardofodds.com/
[7] Brown, A., & Sandholm, T. (2017). Superhuman AI for heads-up no-limit poker: Libratus beats top professionals. Science, 359(6374), 418–424.
[8] Werthamer, N. R. (2009). Risk and Reward: The Science of Casino Blackjack. Springer.
[9] Grosjean, J. (2009). Beyond Counting: Exploiting Casino Games from Blackjack to Video Poker. South Side Advantage Press.
[10] Ross, S. M. (2019). A First Course in Probability (10th ed.). Pearson.
[11] Hogg, R. V., McKean, J., & Craig, A. T. (2019). Introduction to Mathematical Statistics (8th ed.).Pearson.
[12] National Council on Problem Gambling. https: //www.ncpgambling.org/