

# Using Simulations to Better Appreciate Game Outcomes: Implications for Bet Minimums and Maximums

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# Using game simulations to shed insight into common gaming behaviours

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Fair games of chance, such as Baccarat, are *exact*: the relevant elements of randomness are known, hence probability theory can be applied to deduce outcomes, notably the *house advantage*.

However, applied probability theory can prove unwieldy for computing the outcome of everyday gambling behaviours, such as betting systems. For example: *how exposed is the house if a winning streak causes a highly skewed player-banker differential?*

Simulation is a proven way to assess possible outcomes in such situations.

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To start: Define the simulation parameters

| Symbol | Meaning | Value | Domain |
|---|---|---|---|
| $n_{max}$ | maximum number of games | 50 | |
| $n$ | game number | | $1 \leq n \leq n_{max}$ |
| $p$ | probability of success for player in 1 game | 0.44625 | |
| $b$ | probability of success for banker in 1 game | 0.45860 | |
| $t$ | probability of tie in 1 game | 0.09515 | |
| $z_n$ | outcome on game n | | $\{P, B, T\}$ |
| $L_n$ | current run length, game n | | |
| $F_n$ | final run length, game n | | |
| $R_n$ | bet of run follower on game n | | $\{P, B\}$ |
| $x_n$ | betting index | | $1 \leq x_n$ |

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**Runs and their lengths**

A run may be a Player run or a Banker run.

**Example of Player run**

We define a player run to be any contiguous sequence of outcomes beginning with a player win and containing no banker win. Ties may appear anywhere in a player run, but may not begin it. A run may be terminated by either a win for the Banker or by the last game (set at 50, the approximate number of plays in a shoe). We define the length of a player run to be simply the number of player wins in the run.

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Examples of various run lengths

| Game #, n | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | Run Length |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Example 1** | **P** | **P** | **P** | **P** | **P** | **B** | | | | | **5** |
| **Example 2** | **P** | **T** | **T** | **P** | **P** | **P** | **B** | | | | **4** |
| **Example 3** | **P** | **T** | **T** | **T** | **B** | | | | | | **1** |
| **Example 4** | **B** | **P** | **P** | **T** | **P** | **P** | **P** | **P** | **T** | **P** | **7** |

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**The run follower**

We propose the existence of a player who follows runs, and call him the run follower (RF). *Management in Macau suggest this is the case as evidenced by a widening differential.* On the first game he bets on Player or Banker with probability 0.5 each. Thereafter, he bets on the same outcome (P or B) as he did on the previous game, unless there is a run of length two on the "other side", in which cases he switches to that side.

RF will stay on the side of a run even if the run breaks. He will only switch allegiance if a run of length 2 becomes evident "on the other side".

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Example of following runs. Here, a follower run length of 5 is achieved – and the player would have *lost* that hand.

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | 0.65 | B | -1 | 0 | B | 1 |
| 19 | 0.97 | T | -1 | -1 | B | 2 |
| 20 | 0.24 | P | 1 | 0 | B | 2 |
| 21 | 0.13 | P | 2 | 0 | B | 1 |
| 22 | 0.08 | P | 3 | 0 | P | 1 |
| 23 | 0.30 | P | 4 | 4 | P | 2 |
| 24 | 0.61 | B | -1 | -1 | P | 3 |
| 25 | 0.24 | P | 1 | 0 | P | 1 |
| 26 | 0.32 | P | 2 | 0 | P | 2 |
| 27 | 0.09 | P | 3 | 0 | P | 3 |
| 28 | 0.95 | T | 3 | 0 | P | 4 |
| 29 | 0.37 | P | 4 | 4 | P | 4 |
| 30 | 0.79 | B | -1 | -1 | P | 5 |
| 31 | 0.40 | P | 1 | 0 | P | 1 |
| 32 | 0.14 | P | 2 | 2 | P | 2 |
| 33 | 0.63 | B | -1 | 0 | P | 3 |
| 34 | 0.69 | B | -2 | 0 | P | 1 |
| 35 | 0.91 | T | -2 | -2 | B | 1 |

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**Betting patterns**

The amount wagered for a hand is a function of the length of “winning runs”. We consider the following betting patterns: constant, linear, an actual observed pattern provided by a local establishment, and two hypothetical bet patterns (we created 2, but any patterns can be inserted).

**Cumulative winnings/losses**

We may now compute cumulative house profits (losses) for each of the betting patterns. *We could determine insights for wins/losses for individual hands.*

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Betting patterns examined. All patterns start with a bet of 100 'units'; the actuals follow an *S-shaped* betting pattern, levelling off at a run of length 10..

| run length | Actuals1* | actuals2 | actuals3 | linear | constant |
|---|---|---|---|---|---|
| 1 | 100 | 100 | 100 | 100 | 100 |
| 2 | 100 | 100 | 100 | 200 | 100 |
| 3 | 133 | 443 | 1200 | 300 | 100 |
| 4 | 315 | 1050 | 10500 | 400 | 100 |
| 5 | 728 | 2427 | 24267 | 500 | 100 |
| 6 | 1064 | 3547 | 35467 | 600 | 100 |
| 7 | 1596 | 5320 | 53200 | 700 | 100 |
| 8 | 2183 | 7277 | 72767 | 800 | 100 |
| 9 | 2911 | 9703 | 97033 | 900 | 100 |
| 10 | 3000 | 10000 | 100000 | 1000 | 100 |

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Insights from the simulation (30,000 shoes of 50 hands each). Performance from a single shoe that had a max run length of 5.

| 30000 | Constant | Linear | Actual1 | Actual2 | Actual3 |
|---|---|---|---|---|---|
| CURRENT SHOE | | | | | |
| Min bet | 100 | 100 | 100 | 100 | 100 |
| Max bet | 100 | 500 | 728 | 2427 | 24267 |
| Total bet (handle) | 5000 | 8000 | 6190 | 10600 | 54367 |
| Net player payout | -625 | -1425 | -1104 | -2689 | -16592 |
| Min player payout | -100 | -500 | -728 | -2427 | -24267 |
| Max player payout | 100 | 400 | 315 | 1050 | 10500 |
| RTP | -12.50% | -17.81% | -17.84% | -25.36% | -30.52% |

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Outcome after 30,000 simulations (about a month's worth of play across 20 tables).

| CUMULATIVE | | | | | |
|---|---|---|---|---|---|
| Prizes | -1587370 | -3045755 | -2901008 | -6693614 | -50996036 |
| Player Contribution | 150000000 | 293756900 | 264054128 | 614046955 | 4521359306 |
| RTP | -1.06% | -1.04% | -1.10% | -1.09% | -1.13% |

| SUMMARY STATISTICS | | | | | |
|---|---|---|---|---|---|
| Min shoe revenue | -2635 | -3535 | -2635 | -5334 | -77278 |
| Max shoe revenue | 2460 | 17010 | 36446 | 121346 | 1213072 |
| Median | -55 | -375 | -655 | -2397 | -18496 |
| Mean | -53 | -102 | -97 | -223 | -1700 |
| Std deviation | 664 | 1559 | 2120 | 6813 | 67212 |
| Skewness | 0 | 1 | 5 | 5 | 5 |
| Kurtosis | 0 | 4 | 32 | 36 | 36 |

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This translates into 1,500,000 hands

| | Player | Banker | Tie | TOTAL |
|---|---|---|---|---|
| Current outcomes | 25 | 17 | 8 | 50 |
| Cumulative outcomes | 669438 | 687899 | 142663 | 1500000 |
| | | | | |
| Sim frequencies | 0.44629 | 0.45860 | 0.095 | 1.000 |
| Expected frequencies | 0.44625 | 0.4586 | 0.095 | 1.000 |

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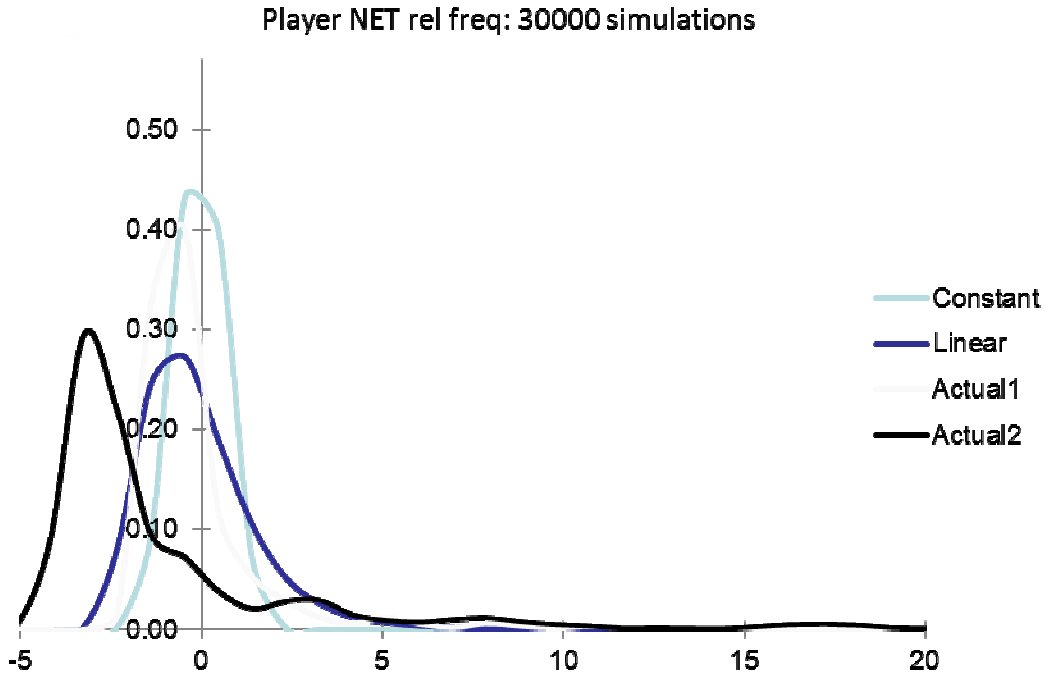
Frequency distribution of net player payouts across the 30,000 simulations. Escalating bets means the player is more likely to lose; but if they win, they can win large amounts.  Note how the mode shifts left as the differential increases.



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Betting patterns can result in “outcome reversals” relative to constant betting. This could result in interesting behavioural ramifications.

| | Non-constant is better | | | | Constant is better | | | |
|---|---|---|---|---|---|---|---|---|
| | Linear | Actual1 | Actual2 | Actual3 | Linear | Actual1 | Actual2 | Actual3 |
| # | 1528 | 1093 | 1525 | 1957 | 3768 | 7529 | 8818 | 9217 |
| % | 0.051 | 0.036 | 0.051 | 0.065 | 0.126 | 0.251 | 0.294 | 0.307 |

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## Conclusion

Regardless of differential (which can be used as a *product differentiation strategy*), the house advantage does not change; but the greater the differential, the greater the number of shoes that end with players losing and the more extreme are the payouts in the positive domain for players (the house paying out for a hand of play).

This simulation is therefore intended to help casino managers set betting limits that maximize total winnings while bearing in mind both the likelihood and magnitude of negative outcomes of increased differentials.

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**Questions?**

**Thank you!**

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