

KEEPING CASINO GAMES FAIR AND HONEST: THE ROLE OF STATISTICAL EVIDENCE IN GAMING REGULATION

*Robert C. Hannum, Daniels College of Business, University of Denver, 2101 S. University Blvd.,
Denver, CO 80208, (303) 871-2115, rhannum@du.edu*

*Anthony N. Cabot, Lionel Sawyer & Collins, 1700 Bank of America Plaza, 300 South Fourth Street, Las
Vegas, NV 89101, (702) 383-8840, acabot@lvcm.com*

ABSTRACT

Although it is common knowledge that the gaming industry is built on a foundation of probability and statistics, it is not so well known how the gaming regulatory process relies on these mathematical underpinnings. Legal standards relating to fairness and honesty of games often include specifications for mathematical analyses and statistical testing to confirm house advantages, verify compliance with regulatory price controls, and ensure randomness of game outcomes. This paper examines this interface between mathematics and gaming regulation.

INTRODUCTION

In 2000, more than \$826 billion was wagered legally on commercial gambling games in the United States, resulting in gross gaming revenues of \$62 billion. Casino gaming, legal in 29 states, accounted for 72% of the handle and 41% of the revenues [3]. Since the gambling business is built on mathematics – numerous sources can be consulted to see exactly how the math produces the game revenues [*e.g.*, 5] – it should not be surprising that mathematical issues arise in gaming law and regulation. A game based on bad math – one whose house advantage is misrepresented, or whose house advantage is too large or small – may not satisfy standards of fairness and honesty, qualities that are paramount to effective gaming regulation. Thus, gaming regulators are concerned with whether slot combinations are selected randomly, cards are dealt from a shuffled deck, rolls of the dice result in random outcomes, the house advantage is within acceptable limits, and the casino is keeping only its fair share of the money wagered – all inherently mathematical considerations. In this paper we examine the role of mathematics and statistics in laws and regulations relating to casino games, devices, and procedures.

FAIRNESS AND HONESTY

Most gaming regulatory systems share common objectives: keep the games fair and honest and assure that players are paid if they win. Fairness and honesty are two different concepts – a casino can be honest but not fair. Honesty refers to whether the casino offers games whose chance elements are random. For example, a slot machine is honest if the outcome of each play is not predetermined in the casino's favor. That same slot machine is not fair if it holds 90% of the money wagered. Fairness refers to the game advantage. How much of each dollar wagered should the casino be able to keep?

REGULATIONS RELATING TO FAIRNESS

Fairness refers to the games being designed so that they do not take unreasonable advantage of the player. It is not uncommon for slot machines to pay back on average 95% of all wagers accepted (about average for 25-cent slots in Nevada). The five-percent retained is a reasonable amount for the casino to

keep to pay for its capital costs, operating expenses and a fair profit. Setting the machines to hold 40%, however, may not be reasonable.

Fairness and Regulatory Price Controls

Unlike most other consumer purchases where the price of a product is fixed, the price of a casino game depends the rules of the game, the payoffs for winning wagers, the amount of time the player plays, the speed of the game, and possibly the skill of the player. Although all these factors may contribute to how much a player ultimately spends, the inherent cost of the game is set by the odds, or more precisely, the house advantage. All else equal, playing a 2% house edge game will cost the player twice as much on average as a 1% house edge game. Casinos set prices on games by (consciously or unconsciously) setting the odds. This may be accomplished through rule variations that are more or less favorable to the player, by altering the payoffs on certain wagers, or by offering a different type of game product. Regardless of the method, the house advantage determines how much it costs a player to play a game.

The government sets rates in the casino industry by dictating odds of the games. For example, a jurisdiction may require that casinos offer no more than double odds on craps (the greater the odds a player can take, the lower the house advantage – a bet on the pass line with double odds faces a 0.61% house edge, 0.47% with triple odds, 0.33% with 5X odds, 0.18% with 10X odds, and 0.02% with 100X odds.), must have roulette tables with 0 and 00 (the house edge on a double-zero wheel is 5.3%; only 2.7% on a single-zero wheel), or use multiple decks in blackjack. With slot machines, these standards are usually defined by setting a minimum payout. In Nevada for example, all gaming devices must theoretically pay out a mathematically demonstrable percentage of all amounts wagered, which must not be less than 75% for each wager available for play [7]. Gaming devices that may be affected by player skill must meet this standard when using a method of play that will provide the greatest return to the player over a period of continuous play. Similar maximum price requirements exist in other jurisdictions. In Mississippi, Colorado, Iowa, and South Dakota, the minimum payout is 80%, while New Jersey and the U.S. Virgin Islands require 83% [1]. Demonstrating compliance with such regulatory controls is largely a mathematical exercise using standard methods of probability theory.

What Fairness Standards Should Apply?

Regulations that set maximum price restrictions tend to be overly general and can present practical problems. For example, special consideration may need to be made for gaming device denomination or table limits, and game pace. An 80% payback on a nickel device with one coin-in and 325 pulls per hour results in an average cost per hour to the player of \$3.25. This may be fair to the player, but unacceptable to the casino operator if the cost of maintaining a gaming device exceeds \$3.25. In contrast, if the player is playing a dollar machine at a 20% advantage with three coins in, the average price is \$195 per hour, arguably an unfair advantage over the player. Maximum price restrictions may actually increase the price of playing if the casino must eliminate low denomination machines or table games that become unprofitable to offer because of such price requirements. This can be partially addressed by having different maximum pricing for different denominations. Similarly, the government may want to take into account the average number of plays per hour and allow the casino to have a higher theoretical win for the slower games.

While governments can easily set maximum theoretical wins based on denomination for gaming devices, there is an inherent difficulty with setting maximum prices on table games. Handle is typically not a measurable quantity for table games [2, p. 433] [5, p. 42] and, except in certain jurisdictions with maximum bet restrictions, table games often allow a range of bets, e.g., from \$5 to \$100. Other practical

considerations include games (such as craps) that allows for different bets with widely varying house advantages, and games involving an element of skill. Should the government ban the bets with a house advantage over the maximum amount or consider a higher average of all bets on the table? In setting the maximum theoretical win in these circumstances, should the regulators consider the most skilled or least skilled players? Average price per hour may be a better standard.

In some states, the government seeks to protect players from losing too much money in any given session. One method is to impose a maximum loss restriction to assure that players do not continue to chase their losses, an activity that over time will assure that they intensify their losses. Another method is to put maximum bet limits. Colorado has a \$5 maximum bet, and South Dakota's is \$100 (recently raised from \$5). While theoretically this limits the potential loss that a player may sustain, it also lowers the casino's volatility and assures that more players end up with a net loss [5, p. 180].

REGULATIONS RELATING TO HONESTY

Regulations relating to honesty attempt to assure that the games produce random results and that these results conform to the approved or represented odds of the game being offered. Regulations can range from standards for random number generators in gaming devices to methodologies to test whether the games are performing as mathematically expected.

Standards to Assure Randomness

Definitions of randomness found in gaming regulations use phrases such as "observed unpredictability" and "absence of pattern." For non-computer controlled games, methods for confirming randomness range from inspections and measurements of equipment to statistical analysis of empirical data. To verify the honesty of dice, for example, precise instruments are used to assure that all of the sides of a pair of dice are the same length and width and are parallel. Likewise, roulette tables can be inspected to assure that they are perfectly balanced. Other evidence may also be required, particularly for devices used in new games seeking regulatory approval. When considering the approval of a new table game that used a new spinner device, for example, the Mississippi Gaming Commission requested a statistical analysis of actual spins to confirm, at the 99% level of confidence, the device produced random outcomes. This request, in addition to requests for other measurement and production related evidence of the spinner's integrity, was made after submission and acceptance of a detailed probability analysis showing the house advantages for each possible bet, along with the overall game advantage [8].

For computer-controlled gaming devices (virtually all those in use today), general requirements include that the random number generator run continuously and have proper seeding, and the outcomes meet minimum confidence levels that the numbers generated are random [2, p. 389]. Nevada standards include that the random selection process used by gaming devices must meet 95% confidence limits using a standard chi-squared test for goodness of fit. Further requirements include that each possible permutation or combination of game elements which produce winning or losing game outcomes must be available for random selection at the initiation of each play. For gaming devices that are representative of live gambling games, the mathematical probability of a symbol or other element appearing in a game outcome must be equal to the mathematical probability of that symbol or element occurring in the live gambling game. For other gaming devices, the mathematical probability of a symbol appearing in a position in any game outcome must be constant. The selection process must not produce detectable patterns of game elements or detectable dependency upon any previous game outcome, the amount wagered, or upon the style or method of play [7].

Mississippi regulations are similar to those of Nevada, but require 99% confidence limits on the chi-squared goodness of fit test. Iowa and Louisiana require that the game in each device shall be random and tested to at least a 99% certainty using a standard correlation test or analysis. Colorado regulations specify that outcomes satisfy at least 99% confidence level using standard chi-squared analysis, the median runs test or any similar pattern-checking statistic, standard correlation analysis, and standard serial correlation analysis. The technical language in these regulations is somewhat sloppy in places. The random selection process standards in Colorado, South Dakota, and Iowa, for example, refer to a chi-squared analysis as “the sum of the squares of the difference between the expected result and the observed result” (omitting the division by the expected result), and the word “random” is used in places where “independent” is the correct term [4] [6] [9].

CONCLUSION

Technical standards in gaming regulations have evolved to a point where regulators now rely on statistics and mathematics to help keep commercial gambling games fair and honest. Whereas in the past, regulations did not specifically address issues such as randomness, independence of outcomes, statistical tests, and confidence limits, such mathematical topics are now recognized for their crucial role in meeting certain regulatory objectives. Many jurisdictions now require specific statistical tests and mathematical analyses to confirm that games outcomes are random, probabilities are as advertised, and house advantages comply with price controls. However, these requirements vary across jurisdictions and in some cases the statistical and mathematical standards are insufficient, carelessly worded, or lacking in detail. Gaming regulators should work with appropriate statistical experts to fine tune and improve current regulations, and when necessary, draft new laws where mathematical and statistical evidence is of utmost importance. With the phenomenal growth of legalized gambling in the last quarter century, and further growth expected – particularly in the area of internet gambling – probability and statistics will continue to command a highly respected position in gaming law and regulation.

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