Slot Machines: Methodologies and Myths

by
Michael L. Kasavana

The proliferation of legalized gaming has significantly changed the nature of the hospitality industry. While several aspects of gaming have flourished, none has become more popular, profitable, or technologically advanced as the slot machine. While more than half of all casino gambling, and earnings, is generated by slot machines, little has been written about the technology integral to these devices. The author describes the workings of computer-controlled slot machines and exposes some of the popular operating myths.

The proliferation of legalized gaming has significantly changed the nature of the hospitality industry. The growth and development of betting parlors, high-stake casinos, and riverboat gambling has created a national attraction. Although several aspects of gaming have flourished, none has been as popular or become as technologically advanced as the slot machine.

More than half of all casino gambling takes place at slot machines, which produce an average return, for the casino, between 85 percent and 97 percent.[1] While rates of return (ie., yield) vary by type of slot machine, some legalized gaming areas have imposed a maximum allowable return percentage; Atlantic City is limited to 83 percent. There are, however, no known parameters which specify a minimum percentage of return for the gambler.

Slot machines have special qualities that contribute to their appeal. Machines are played privately, require no instruction, and have few playing rules. Since slot machines typically require no specialized skill, they are usually classified as gambling devices. When a specialty slot machine is skill-based (i.e., the skill of the player can influence the outcome), then the machine is referred to as a gaming device.

Slot machines have evolved from mechanical to electro-mechanical to microprocessor-controlled devices. Prior to 1960, slot machines were mechanical in nature. Early slot machines contained a handle that initiated the game's action. It is for this reason that the machine became known as a "one-arm bandit." When a coin was inserted and the handle pulled, a set of spinning reels began rotating. It was the player's

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fascination with the spinning reels that many experts credit with having boosted the popularity of slot machines. In mechanical action slots, a machine-based payoff was derived from winning combinations of symbols on the spinning reels and ranged from five cents to a maximum of $25. While most machine-generated payouts were small, some larger payouts were possible. Payouts greater than $25, for example, typically had to be paid by a casino attendant.

During the late 1960s, casinos began installing electro-mechanical slot machines. These devices were capable of monitoring multiple coin plays and multiple line pays, as well as charting progressive jackpots. Despite the inherent improvements from technology, the verification, payout, and tracking of jackpots remained a manual procedure. There were, however, some additional anti-cheating safeguards which were built into electro-mechanical devices which were not present in predecessor machines. Coin meters, flashing lights, noise makers, and huge coin hoppers rendered machines capable of automatically paying jackpots in excess of $25.

Solid State Units Were More Reliable

In the late 1970s, electro-mechanical slot machines evolved rapidly into solid state units equipped with highly reliable microprocessor components. Microprocessor-based machines, which rely upon computer chips to control internal system functions, typically contain a large video screen, 13 inches or more and a set of control buttons. Usually a set of computer chips is reserved for the generation of win-loss symbols and the tracking of machine-based operations.

Microprocessor-based machines are dependent upon payout algorithms (formulae) and a random number generator (RNG). The inner workings of a microprocessor-based device involve the internal algorithm generating a set of random numbers which are, in turn, translated into symbols to be displayed on the machine's video screen. Hence, an important component within the machine is its RNG. In any computer-based slot machine, the RNG is in perpetual motion, constantly producing random numbers. The RNG virtually selects a feasible number from a pre-specified range of values every millisecond. Most microprocessor-based slot machines use a 32-bit RNG which means the RNG will generate a number somewhere between 0 and 4 billion (i.e., 4,294,967,296 or exponentially 2 to the 32nd power).

While it may appear logical to expect that each number in the range would be selected before any given number is repeated, this may or may not be the case. Basically, the RNG works continuously regardless of whether anyone is playing the machine. At a specific point in the player/machine interaction (eg., coin insertion), the unit's active random number generator will convert a derived value into slot machine symbols. These symbols are then displayed and the amount of payout is automatically determined and subsequently paid.

Computer-based slot machines operate by keying on individual player-instigated action (PIA), a pre-programmed event within the

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computer program. This event could be triggered at the time a coin is inserted, registered, or metered by the machine or at the time a button is pressed or some other pre-defined action occurs. Once initiated, the PIA is used to instruct the RNG to translate its current contents into symbols. It is the combination of millisecond PIA timing and broad-ranging RNG randomness that significantly inhibits a player's ability to affect the machine's outcome. The average player has a 50 to 350 millisecond reaction time while a normal slot machine produces a new data set every 16 to 50 milliseconds; this further highlights the machine's inherent security.

Since the RNG, in combination with the PIA, determines when a jackpot is to be paid, there is little sense in assuming that because a machine has not recently paid out, there is a greater likelihood of predicting its behavior. In addition to the internal timing mechanism of the machine, there are numerous on-going reliability audits performed on all machine-based functions to ensure proper payouts and security.

Microprocessor-based slot machines do not depend on a handle for game initiation. A push button can be used for this purpose. Most microprocessor-based machines have replaced mechanical spinning reels with a video equivalent. By using creative video, manufacturers have been able to simulate the movement and fascination of the original machinery. Some vendors, however, continue to produce microprocessor machines that contain real spinning reels controlled by a stepper motor. These machines more closely resemble the action of earlier models and tend to be well received by players.

Slot Machine Components Are Standard

Although there are an array of specialty slot machines, a set of standard components can be delineated. Common elements include the following:

- **symbols:** used to identify locations on a spinning reel
- **spinning reel:** a wheel-like device that contains symbols ,or symbols simulated through video motion
- **coin slot:** a mechanical device used to capture a wager and to initiate game activity; in some machines the number of coins directly effects the value of a potential payout
- **handle/button:** a physical, external part used to initiate reel action by the player

Together these components form the basis for a machine configuration.

The three basic slot machine configurations are multiplier, multiple line, and buy-your-pay. Since current slot machine production consists of multiple coin machines, single coin and/or single line machines are considered obsolete. All three rely upon multiple coin wagering as follows:

- **Multiplier configuration:** A multiplier machine allows a player to increase winnings proportionately by playing multiple coins.

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Some machines offer an additional incentive jackpot bonus for those players electing to play the maximum number of coins. Common multiplier machines include two, three, four and five coin operations; there are, however, some machines capable of accepting up to 10 coins per play.

• **Multiple line configuration:** A multiple line machine is capable of returning winnings and jackpot values on more than one line. Most common multiple line machines are of a three or five-line diagonally-crossed type; some machines offer up to eight patterned lines. Multiple line machines require a coin to be played for each payout line. Only lines played are paid if hit. The greatest potential jackpot in a multiple line machine is paid only when the highest numbered line is activated.

• **Buy-your-pay configuration:** A buy-your-pay slot machine contains a single payout line that enables the player to multiply payouts by the number of coins played. These machines differ from multiplier machines in that they do not pay unless both the increased number of coins and the exact winning combination of symbols are hit.

For example, on a three-coin machine, the cherry symbols may be paid only on the first coin. If you insert two coins and three cherry symbols were displayed, there would be no payout. To win on three orange symbols, for example, the player may have had to insert exactly three coins. There are two, three, and four coin machines with varying symbols scattered among a complex payout table. A buy-your-pay machine tend to have a comparatively low player payout percentage and often is referred to as a "lose-your-pay" machine.

Winning Percentages Are Complicated

The calculation of a payback percentage for a slot machine is a relatively straight-forward procedure. Its complexity increases, however, as the number of winning combinations or number of spinning reels increases. Originally, slot machines had 20 positions, or stops, on each spinning reel. This meant that on a three-reel slot machine, there were 20 X 20 X 20 or 8,000 different combinations of positions where the reels could stop. The slot machine term for these combinations is "cycle." In theory, if a player played the machine 8,000 times, he/she would see every possible combination once. In reality, this just isn't the case. There are some combinations of symbols which may cycle frequently and some that might never appear. It may take playing the machine 80,000 or 800,000 times to see every possible combination. The longer the machine is played, the closer the actual results will be to the theoretical average.

For example, if there is one "7" on each reel, and there are three reels each containing 20 symbols, then the player would have a 1 X 1 X 1 = 1 chance in 8,000 possible combinations of hitting three 7s simultaneously on the payout line. If there were four cherries on each reel, then the chance for hitting three cherries on the same line (one on each reel of the payout line) would be 4 X 4 X 4 = 64 combinations among

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Figure 1
Slot Machine Yield Example

Machine No.	Theory Handle	Hold	Yield	Yield
1122	13742.30	3153.65	22.9	17.0
1123	14154.85	3222.40	22.7	17.0
1124	14259.85	3102.85	21.8	17.0
1125	11595.35	2275.60	19.6	18.8
1126	22272.65	2782.65	12.5	11.3
Totals:	76025.00	14537.15	19.1	

8,000. Hence, the machine is programmed to pay less for three cherries, which has a higher probability of occurrence, than for three 7's on the payout line. The factoring of all possible combinations, called "reel strips," are used to develop payout tables which are programmed into each machine.

When playing a mechanical or electro-mechanical machine, the player could watch the reels actually spin and try to count the symbols in order to attempt to determine winning percentages. Microprocessor-based machines have negated such efforts since there are actually no moving reels. The machine simply provides a blurred display of partial symbols to visually simulate the action of earlier machines. In a microprocessor machine, the displayed movements may have nothing to do with the outcome of a play. Most microprocessor-based machines have 256 symbols per "reel" and, therefore, the odds of hitting the highest paying jackpot would be 1 in 16 million or more 256 X 256 X 256 = 16,777,216.

Slot Machine Yields Are Tracked

Additional external computers are counted on to monitor slot machine activity and performance. Slot machine payout data is continuously tracked and typically aggregated on a weekly, monthly, and year-to-date (YTD) basis. The term "handle" is used to describe the total of all coins inserted into in a slot machine by its players. The term "hold" or "win" is used to describe the amount of money the casino retains as profit. The machine's "yield" or "hold percentage" is found by dividing hold as a percentage of the handle. Consider the example contained in Figure 1.

The performance of a slot machine is evaluated by comparing its actual yield to its theoretical yield. For the machine data contained in Figure 1, a comparison of actual and theoretical yield data shows the machines are performing better than expected. Each has an actual yield that is higher than its theoretical yield. When a machine's actual yield is below its theoretical yield, this indicates the machine may be performing poorly (i.e., paying out too frequently).

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The ranked order of popularity for machine games, according to several gaming sources, is as follows:

1. Slot Machines
2. Video 5 Card Draw Poker
3. Video Keno
4. Video Blackjack or "21"
5. Video Horse Racing
6. Paddle Pushing ("Flip-It" or "Whirl-Win")
7. Video Craps
8. Video Roulette
9. Video Bingo

Player Motivations Often Change

Often people engaged in gaming or gambling may lose track of their original motivation. They may have initiated play as a form of entertainment, but may transcend into a psychological trap fueled by frustration, competitiveness, or greed. Too often players continue to play even when faced with the proposition that the game may no longer provide the original value sought. In fact, they may actually intensify their behavior, despite a lack of success or a diminishment of return. Not knowing when to cut losses can be a risky endeavor, one which leads a player's motivation to change.

A common set of psychological issues and motivations underlies a process referred to as psychological entrapment. Similar to the Chinese Finger Trap, a straw cylinder into which a finger from each hand is inserted into each end, the more one tries to free him/herself from the trap, the tighter the trap's grip. The only way to free one's fingers from the trap is to move counter to the direction in which the escape appears to lie. In the finger trap the secret is to push the two fingers toward one another, not pull them apart. Pulling them outwardly only tightens the clench of the trap around each finger. In other words, the tighter one pulls to get free, the more intense the trap's grip.

This is somewhat analogous to a player's motivation in a gaming or gambling environment. There tends to be an increasing conflict between the lure of a goal (jackpot) and the increasing cost of remaining in pursuit (investment).

Researchers note there are basically two major motivational categories: economic and interpersonal. In the case of slot machine play, the economic motivation may be the desire to win the jackpot, regain prior losses, or avoid losing more money. Interpersonal motivations might include the need to avoid embarrassment, to prove the player's skill, or to punish the slot machine. Early in a gambling session, the player probably begins with a strong economic motive, hoping to win the jackpot and thereby have a significant economic gain. Over time, interpersonal motivation likely takes control, especially when the player realizes that the amount of money being wagered exceeds the reasonable limits established in advance of the session. To continue playing, even when it appears that winnings cannot equal earlier

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losses, illustrates the shift in player motivation from economic to interpersonal.

Understanding player motivation may well explain why a player might choose a slot machine over a live action casino game. Slot machines allow the player to play at his/her own pace. In addition, they minimize potential player embarrassment from making a naive move. The fact is self-paced machine play assists the player with learning and experimenting with various game strategies, and thereby may misdirect the player away from his/her initial motivations.

Slot Machine Myths

There are many myths associated with slot machine play. The six most common myths are the following:

- **Myth #1:** A smart slot player should always select a machine nearest the door or on the end of an aisle since higher payback machines are always placed in higher traffic areas to attract players.

This myth is simply untrue! Since most casinos have an excess of players and a shortage of machines, there simply is no need to lure gamblers and to position specially modified (illegal) machines.

- **Myth #2:** A machine that contains cold coins is less likely to pay out since the coins have not been stored in the machine long enough to warm up. Or, conversely, a machine that pays out in warm temperature coins indicates that the machine has held the coins too long and therefore may have a history of infrequent payouts.

This myth is based on the uninformed notion that the only way coins are warmed by a machine is through extended duration in machine storage. The idea that warm coins indicates long droughts between payouts is unfounded. Similarly, cold coin payouts are not indicative of coins that have not been in a machine very long. The assumption that cold coins are associated with "loose" machines is silly. The fact is neither coin temperature or coin storage duration have any influence on the machine's payout activity.

- **Myth #3:** The longer one plays a machine, the more likely it is to pay out.

Of all the slot machine myths, this one is perhaps the most widely held. There simply is no logical basis for such belief. Slot machines simply do not possess a timing device for regulating jackpot cycles. Even though some machines may be observed paying small jackpots with regularity, these same machines may or may not pay a big jackpot for months or years, if ever.

- **Myth #4:** Watch for someone who has played a machine for some time without winning; play that machine since it is now ready to pay.

This myth is another example of a falsehood based on predictable frequency of payout. There is no scientific data to support such a claim.

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There is no correlation between wagered bets and payout cycling. The fact that someone is believed to have "warmed up" a machine does not render the machine any more likely to distribute winnings.

• **Myth #5:** Casinos can control frequency of payouts by flipping a switch on the back of a slot machine.

Not true. In fact, it is illegal to have any such attachment connected to a gaming device. Casino personnel are not allowed to influence the outcome of any gaming or gambling activity.

• **Myth #6:** The higher the coin denomination of the machine, the higher the percentage of payout.

There is no correlation between the coin denomination and payout frequency. All machines are programmed with a set of theoretical payout percentages. There is no logical reason to believe that a one dollar slot machine will pay a jackpot more frequently than a quarter machine.

While the growth of casino operations is expected to continue, there is an anticipation of a variety of innovative opportunities to increase player action. For example, there may be a slot machine placed in each hotel guest room with perhaps a companion on-line access to a player's personal finances. There may well be PC-links to casinos or live sporting events or even off-track betting parlors.

In addition, there may be remote gaming monitors for in-home capabilities and/or home links to casinos. Some casinos are experimenting with debit or smart cards which enable cashless slot machine action. The player simply inserts the card into the machine and plays against credit or deposited cash balances. This leaves the player without the burden of handling bulky and dirty coins and allows them to gamble more freely. It is important to remember that casino credit is similar to credit obtained at any other institution. It must be paid back!

Reference

[1]Dwight and Louise Crevelt, *Slot Machine Mania* (Grand Rapids, MI: Gollehon Books, 1989), p. 5.

Michael L. Kasavana is a professor of Hospitality Information Systems in the School of Hotel, Restaurant and Institutional Management at Michigan State University.

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