

Video Poker in South Carolina: A Mathematical Study

by

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Since its debut in South Carolina in 1986, video poker has become a game of great popularity as well as a game of great controversy. Its popularity is demonstrated by the fact that South Carolina currently has over 33,000 video poker machines found in all kinds of establishments throughout the state including service stations, convenience stores, restaurants, bars, and coin-operated laundries. The controversy is evidenced by the fact that numerous organizations have been formed on both sides of the issue to either defend the benefits of the game to the state or to argue its destructive aspects in our society.

The question of whether or not video poker would remain legal in this state was to be the sole purpose of a referendum to take place on November 2, 1999—yet a second referendum on the subject—but the state Supreme Court ruled that that referendum was unconstitutional. As a result, there will be no referendum, and if another part of the court ruling stands, then cash payments for video poker will be banned in the state after June 30, 2000. That latter ruling, however, is likely to face strong opposition by gambling proponents.

The present article is a summary of some of the mathematical findings of a Master's degree thesis currently being written in the Department of Mathematical Sciences at Clemson University by the second named author under the direction of the first. This thesis will be presented and defended in its final form early next year and will be a purely mathematical study in which the author takes neither side of the issue. Rather, with the aid of computers and the theory of probability, the thesis examines the precise moves which should be made by a player for optimum expected return, and assuming such play¹, reports the probabilities and expected returns of various forms of the game currently existing in South Carolina. Here we report some of the results of the thesis with very little of the mathematical or computational details.

Many people who argue about video poker know little or nothing about the actual play of the game, but the mechanics of play are really rather simple. A player wagers one or more coins per game and receives a hand of five cards. The type of coin wagered varies from machine to machine, but is typically a nickel, a dime, or a quarter (although there are dollar machines in some casinos). The player looks over the cards and has the option of discarding any or all of these cards which do not appear desirable. This means that the player has $32 (= 2^5)$ different ways to play the hand since each one of the five cards can be held or discarded. After discarding any undesirable cards, the player is dealt replacements for the ones thrown away.

¹ This kind of play is difficult to attain without a computer but it does serve a benchmark for comparing various strategies and video poker machines.

The resulting hand is then compared to a list of various types of winning poker hands, each of which is associated with a particular payoff. If the player has obtained one of the winning hands, he or she is rewarded an amount of money equal to the payoff² for each coin wagered. No payoff is made to the player unless the hand matches one in the list, and in any event, the player loses the deposited coins. At this point, the game is over, but the player can continue to play new games until he or she decides to stop or has no money with which to play.

Note that video poker is not played against another opponent, and it involves only a single bet per game; namely the deposited coins. Consequently, video poker does not share many of the elements of regular poker such as raising or bluffing. Surprisingly, some novice players do not know even these simple facts about the game.

For purposes of this study, the assumption was made that the video poker machines in South Carolina deal cards fairly in the sense that each of the potential hands has the same probability of being dealt. Further, it was assumed that each new hand is dealt independently from the previous hands. These assumptions are needed for the mathematical analysis and they seem reasonable on several accounts. In the first place, the overall payouts can be controlled by changing the payoff tables for the winning hands, so there is really no need for underhanded or hidden tactics. Secondly, the state of Nevada requires these fairness features in its machines and the random number generators which go into machines used in that state must pass strict “randomness” tests. It is likely that some of the machines from the same assembly lines have gone to both South Carolina and Nevada as well as other gaming establishments.

Of particular significance to professional gamblers (including expert video poker players and indeed to many folks involved in risky ventures including investing in the stock market) is a concept called the expected value or expected return. This concept is used heavily in the thesis in determining the optimal strategy but the details are not appropriate for this article. However, we shall give the reader an idea of this concept and how it is used in decision making with a simple “game show” example.

Consider a game show in which you, the contestant, have the option of selecting one of three doors and assume that behind each door is a certain amount of money. Figure 1 below gives one such scenario (but, as the contestant, you do not know what is behind the doors).

² If the hand matches more than one entry in the list of winning hands, the player receives the reward associated with the highest hand type.

1	2	3
Contents \$60	Contents \$30	Contents \$120

Figure 1: Possible “game show” scenerio

In this game, you select a door at random (and we assume a one-third chance for each door) and receive the amount of money behind that door. Your expected return for the game is \$70 as determined by the equation

$$(\$60 \times 1/3) + (\$30 \times 1/3) + (\$120 \times 1/3) = \$20 + \$10 + \$40 = \$70$$

Here we have multiplied the various payments by their corresponding probabilities of occurrence and summed the results. As the contestant, you generally get to play the game only once, but the interpretation is that if you were to play it many times, your long term average gain per game would be about \$70. Of course, if you had to put up \$80 to play the game in the first place (unusual for game shows), your expected return would be $\$70 - \$80 = -\$10$, meaning an average loss of \$10 per game. On the other hand, if you had to pay only \$60 to play the game, your expected return would be $\$70 - \$60 = \$10$, implying an average gain of \$10 per game.

Now consider the above game (where you play free for appearing on the show) and suppose you have selected a door. Also assume that you know the dollar amounts for the three doors, but not the specifics behind each individual door, and suppose that the game show host then opens your door revealing a prize of \$60. The question is: What would you do if the host then gave you the option of staying with the \$60 or switching to another door? The professional gambler would pick the option that maximizes the expected return. Here, if you stay, your expected return is \$60, but if you switch, your expected return is \$75; that is,

$$(\$30 \times 1/2) + (\$120 \times 1/2) = \$15 + \$60 = \$75$$

Thus, the professional would switch. Of course, the dollars amounts could be changed into a situation in which it is wise to stay and also into a situation in which the expected returns would be the same for staying or for switching.

The decision process of the above example illustrates a similar feature found in video poker which makes the game very interesting to study — a player gets to make a choice in the process of playing the game. Numerous books have been written regarding various strategies for making that choice. “Perfect play” is obtained by considering every hand that can be dealt (exactly 2,598,960 of them when the order in which the cards are dealt is ignored!), and then picking the best hold-

discard possibility for each hand. This best possibility is determined by calculating the expected return for each of the 32 actions one can take with a given hand and selecting the action which offers the highest expected return for that hand. One can then sum the 2,598,960 best-action expected returns and arrive at the expected return for the machine under perfect play.

Incidentally, even with a computer which could analyze a thousand hands per second, the process just described could take several years to complete if not done efficiently. However, by using the rules of probability and some computational techniques, it is possible to reduce this time to just a few minutes. The thesis explores these issues in detail.

It is extremely difficult (perhaps impossible) to memorize the over two and a half million cases for optimum play. As a result, gambling experts have devised strategies that reduce the number of cases to about fifty or fewer at a cost of a tiny fraction of the expected return. There are many of these “expert strategies”, each with a particular trade off between simplicity and expected return.

With this background, it is now possible to discuss video poker in South Carolina. The three most popular varieties in the state are (i) “Jacks-or-Better” which contains no wild cards ¹, (ii) “Joker’s Wild” which adds one joker to the deck of cards, and (iii) “Deuce’s Wild” which does not contain a joker but all cards with denomination two are wild. Most other varieties are spinoffs of one of these three types. Each machine is further classified according to the various payoffs for the winning hands and is advertised to the player in a “Payoff Table” which is required to be displayed on the machine. The standard version of each machine type is called a “full-pay” machine and has a payoff table typically found in the casinos. Some machine manufacturers take advantage of the fact that people do not read the tables and set the payoff values to much lower values than the full-pay machines. Expert players read the tables and avoid using the lower paying machines.

It is reported in the gaming literature that the full-pay Jacks-or-Better machine has an expected payoff of 99.54% if played perfectly (and about 99.53% if played expertly). This means that for every \$100 put into one of these full-pay machines, the player can expect to get about \$99.54 in return. By studying this standard game with computer simulations and calculations done for the thesis, this claim has been verified. Of course, this payoff percentage assumes that the player knows the expert strategies and plays these strategies with no or very few mistakes. A player who does not use an expert strategy plays at a much lower expected return (60 to 80 percent by some accounts) and loses money at a much faster rate than the expert player. Thus, a lack of knowledge about the game is one of the greatest factors explaining why people lose so much money on these games. A second major factor is the lower payoff tables found in some of the machines, and a third major factor is the imposition of state regulations.

³ A wild card is a card that can substitute for any card.

Because of South Carolina’s restriction of the maximum payout to \$125 per day (which began to be strictly enforced only in the summer of 1999), it is hard to now find a video poker machine in South Carolina which, even when optimally played in the Jacks-or-Better mode, has an expected return anywhere near the full-pay version of 99.54%. The best machine we have seen in the Clemson area is a nickel machine from which one can get a 97.2233% return if played perfectly. When playing this machine, the expert player will lose money about six times faster than he or she would on the full-pay nickel machine in Las Vegas. Figure 2 below gives the results of a computer simulation of a million games under optimum play on three Jacks-or-Better machines with different payoff tables. The line in green represents a full-pay machine found in Las Vegas, the line in blue represents the 97.2233% return machine found near Clemson, and the line in red represents a 91.3958% return machine also found near Clemson.

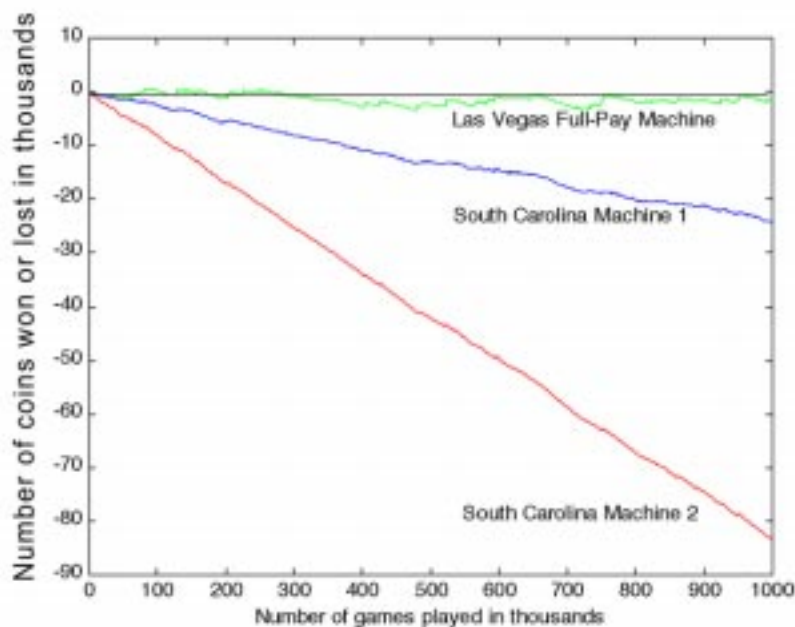


Figure 2: Simulations of Three “Jacks-or-Better” Machines

A surprising finding for us concerned the Joker’s Wild and Deuce’s Wild machines in their “full-pay” versions found in casinos. If played optimally, these games have expected returns of 100.64% and 100.76%, respectively, and consequently are *winning* games for the player. This is unusual since most casino games (e.g., roulette and craps) have negative expected returns, and further, for other casino games like blackjack or twenty-one where experts have been able to devised winning strategies (e.g., by counting cards) there have been rule changes to take away the player’s advantage (e.g., dealing with multiple-decks and forbidding counting at the tables).

It should be emphasized that the above positive statistics for video poker assume the player plays the game expertly over a long period of time. In the short term, the player must be willing to go deep into debt before hitting the jackpot which occurs, on the average, about once every 40,000 games. In the long term, the player will go through repeated cycles of going deep into debt and

then hitting the jackpot to replenish his or her funds. Of course, the jackpot can occur before 40,000 games but it also can occur much later, so the player must be willing to suffer big losses at points in the gambling session (around \$750 or more on the nickel machines and five times that amount on the quarter machines). However, if the expert plays 40 hours per week for 2 years or more, he or she will have an extremely high probability of obtaining a profit from the game. Thus, with a reasonable cushion of money, an expert can earn a positive wage by playing the winning machines.

To give an idea of what kind wage the professional can earn on these good machines, two important factors must be considered; namely, how much the expert can bet on a single game and how fast the expert can play the games. It so happens that a player with some experience can play about 600 games an hour (faster with more experience or if one plays two machines side-by-side at the same time, one in each hand). Assuming perfect play, a play rate of 600 games per hour, bets of \$1.25 per game (the maximum allowable on some quarter machines), and an expected return of 100.64%, a video poker professional can earn, on average, a wage of \$4.80 per hour. This same expert would have to increase the play rate to 644 games per hour to earn the current minimum wage of \$5.15 an hour.

We now briefly return to the discussion of the “mathematical” effects of South Carolina’s maximum pay limit of \$125. The full-pay machine found in casinos pays its jackpot hand (a royal straight flush) at a payoff rate of 800 to 1 (if five coins are bet). Even on a nickel machine, this represents a payoff of \$200 which is more than the legal limit in South Carolina. Thus, to comply with the state’s restrictions, many video poker owners have had to lower the payoff of the jackpot even on the nickel machines (and many have converted quarter machines into nickel machines so that the jackpot payoff is more reasonable for the investment).

Thus, the mathematical effect of the existing payoff limit is that (i) it has reduced the expected return on nearly all South Carolina machines and (ii) it has transformed the perfect-play winning games on the fairest machines into losing games. Had the proposed referendum taken place and the measure passed, the cap would have been raised to \$500 which would have raised the jackpot payoff to 400 to 1 on quarter machines, but this is still not enough to turn these machines back into winners.

Figure 3 below gives the simulated results for a million plays on three different “Deuce’s Wild” machines. The green line again represents a full-pay “winning” machine as found in Las Vegas, the blue line represents the same machine with the jackpot reduced to 400:1 (which can be interpreted as a “good” South Carolina machine had the referendum passed with a \$500 cap on payouts), and the red line represents a typical “good” machine as found in South Carolina with current payout restrictions.

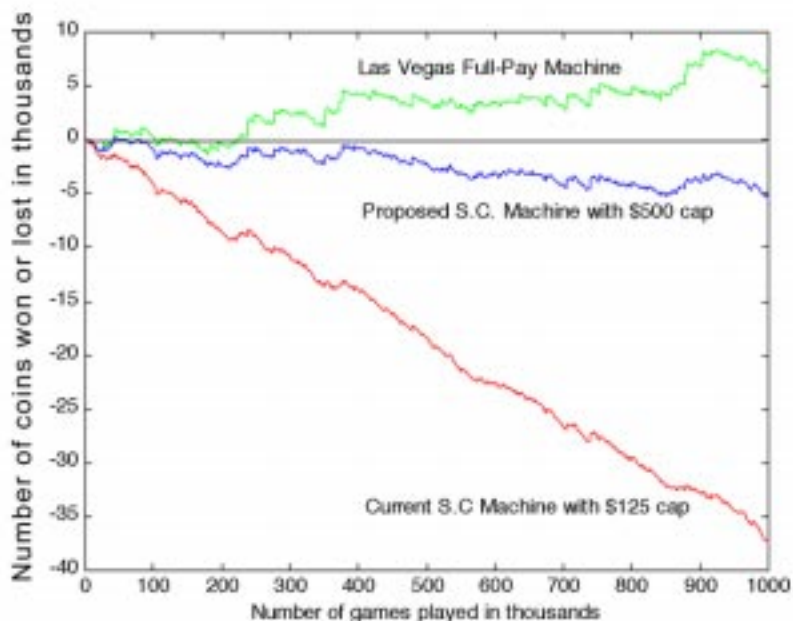


Figure 3: Simulations of Three “Deuce’s Wild” Machines

It should also be noted that as a result of South Carolina’s payoff restrictions, the best video poker players have generally stopped playing the games because they understand the odds. On the other hand, the less knowledgeable players are losing more money.

As a land grant university, one of the responsibilities of Clemson University is to undertake research which has the potential to benefit the citizens of this state. If this report (and the associated master’s thesis on which it is founded) in some small way helps voters, lawmakers, video poker players, or video poker owners better understand the issues, or if it contributes to a rational basis for decision and policy making, then we will be pleased. In any event, it has been a very interesting mathematical project and a rewarding experience in which both the student and the professor have learned a great deal.

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