Toward Legalization of Poker: The Skill vs. Chance Debate

*Robert C. Hannum**
Anthony N. Cabot

Abstract

This paper sheds light on the age-old argument as to whether poker is a game in which skill predominates over chance or vice versa. Recent work addressing the issue of skill vs. chance is reviewed. This current study considers two different scenarios to address the issue: 1) a mathematical analysis supported by computer simulations of one random player and one skilled player in Texas Hold'Em, and 2) full-table simulation games of Texas Hold'Em and Seven Card Stud. Findings for scenario 1 showed the skilled player winning 97 percent of the hands. Findings for scenario 2 further reinforced that highly skilled players convincingly beat unskilled players. Following this study that shows poker as predominantly a skill game, various gaming jurisdictions might declare poker as such, thus legalizing and broadening the game for new venues, new markets, new demographics, and new media. Internet gaming in particular could be expanded and released from its current illegality in the U.S. with benefits accruing to casinos who wish to offer online poker.

Keywords: Poker, games of skill, games of chance, mathematics

The game of poker has become enormously popular over the last decade, in large part due to significantly increased Internet and television exposure. Tournament poker, in particular, has become a viable spectator sport with the advent of specialized cameras that allow the television audience to view the hidden cards of the players. This increased popularity and the uneven legal standing of the game in various jurisdictions has resulted in considerable media attention as well as debates over whether certain forms of poker should be legalized. Central to that debate is whether poker should be treated as a game of skill or chance.

If skill predominates over chance, poker would be considered lawful under most legal standards; if chance predominates over skill, then poker would be deemed illegal under most interpretations of the laws of the federal and state governments (Cabot & Hannum, 2005). In general, prohibited gambling involves any activity in which the following elements are present: (1) the award of a prize, (2) outcome determined on the basis of chance, and (3) where consideration is paid (*see, e.g.*, Cabot & Csoka, 2004, and the references cited therein). If, however, any of these three elements is missing, then the activity may be allowed. Most states exempt skill games from criminal gambling prohibitions (Cabot & Csoka, 2007, pp. 1202-1211).

Three recent legal cases decided in the United States in early 2009 are illustrative of the importance of the skill versus chance debate in poker. In January, a jury in Colorado found the organizer of a poker league not guilty of illegal gambling. The outcome of the trial hinged on whether poker is a game of skill or a game of chance; the jury agreed with expert testimony presented by a statistician that poker is a game of skill (Geller, 2009; Jenkins, 2009). Also in January, a Pennsylvania judge agreed with a defense attorney's arguments in ruling that skill is the predominant factor in poker and dismissed charges against two people who ran a poker game out of a garage. It may have been

Robert C. Hannum*
(Contact author)
Professor
Dept. of Statistics &
Operations Technology
Daniels College of Business
University of Denver
2101 S. University Blvd.
Denver, CO 80208
Tel: (303) 871-2115
Fax: (303) 871-2297
Email: rhannum@du.edu

Anthony N. Cabot
Partner
Lewis and Roca
3993 Howard Hughes Pkwy,
Suite 600
Las Vegas, NV 89169
Tel: (702) 949-8280
Fax: (702) 949-8367
Email: acabot@lrlaw.com

gambling but not unlawfully so, because the outcome of the games had more to do with skill than chance, Judge Thomas James Jr. ruled (Rotstein, 2009). In a February trial of five defendants arrested in a raid on a home poker game in South Carolina, the judge agreed with the testimony of two experts in finding that Texas Hold'em is a game of skill, observing that the evidence and studies are overwhelming that this is so. Noting that the dominant factor test has been accepted in similar rulings in other courts, such as Pennsylvania, California, Missouri, and Nebraska, however, the judge could not justify the use of the predominance test over the South Carolina law that refers to 'any house used as a place of gaming' and found the defendants guilty (Newell, 2009). In ruling that poker is a game of skill, the trial court recognized that this would be an easy case for acquittal if the proper test under South Carolina law is whether a game is predominantly one of skill. The judge concluded, however, that a higher court must decide that issue (Polson, 2009). The five South Carolina defendants are appealing their convictions (Kropf, 2009).

Poker differs in substantial respect from the various activities often classified as gambling, such as lotteries and most casino-style games, because poker has many elements of skill not present in traditional games of chance, such as lotteries and other casino games. This paper addresses the question of skill versus chance in poker and supports the notion that poker is a game of skill.

Related Work

There are a number of scientific studies addressing the issue of skill in poker as well as a plethora of references to same in the more general poker literature. These two collections of works are summarized in the subsections below.

Scientific Studies

Kadane (1986) compared a 'dumb' strategy and a 'smart' strategy to argue that success at electronic draw poker depends a great deal on the player's skill. This conclusion was based on the fact that the smart strategy resulted in four times as many wins/points as the dumb strategy. Kadane emphasizes that in electronic draw poker, skill means that there are decisions under the control of the player that greatly influence the ultimate outcome, an interpretation that could well apply to other gambling games.

Larkey, Kadane, Austin, & Zamir (1997), operating on the premise that skill and skill differences among players are important features of real games, use a simplified version of stud poker to better understand the concept of differential player skill in games. Using computerized experiments, the authors compared twelve different strategies for this simplified poker game, ranging from a simple strategy that plays randomly (which the authors argue is a player with no skill) through progressively more sophisticated strategies utilizing varying degrees of skill. The results show a wide range of outcomes across the different strategies, with better outcomes generally associated with higher degrees of skill. The simple random strategy (zero skill) is the worst overall performer in terms of winnings.

Cabot & Hannum (2005) explored the origins and purposes of poker laws and the predominance test, suggesting that the current public policy debate over gambling should consider games of skill, including variants of poker, from a different perspective than games of chance. In addressing the skill element of poker, these authors analyzed the performance of highly skilled players against one or more less skilled players in simulated games of limit Texas Hold'Em. The results showed that the highly skilled players beat the low skill players convincingly in a variety of player-mix scenarios.

Alon (2007) conducted a detailed analysis of several simplified models of poker, which can be viewed as toy models of Texas Hold'Em. The author notes that the simplified models allow a precise mathematical analysis and yet capture many of the main properties of the more complicated real game. The analysis suggests that skill plays

an important role in poker. Alon concludes that "skill is far more dominant than luck, and that poker is predominately a game of skill" (p. 17).

Croson, Fishman, & Pope (2008) present evidence of skill differentials among poker players finishing in one of the final two tables in high-stakes Texas Hold'Em tournaments between 2001 and 2005 (data included 899 players in 81 separate tournaments). Their main conclusion is that "there appears to be a significant skill component to poker: Previous finishes in tournaments predict current finishes" (p. 28). Using additional data from professional golf tournaments, the authors compare poker to golf, a game universally held to be predominantly skill-based. The authors conclude that "skill differences among top poker players are similar to skill differences across top golfers" (p. 28).

Dedonno & Detterman (2008) examine whether poker is a game of luck or skill by comparing players who were taught strategies based on expert opinion with other players who were taught no strategies. Participants who were instructed out-performed those who were not instructed. The authors conclude: "The unequivocal finding is that poker is a game of skill" (p. 36). They further observe that the skill involved in poker is complex and luck (random factors) disguises the fact that poker is a game of skill.

Fiedler and Rock (2009) propose a 'critical repetition frequency,' defined as the threshold of repetitions at which a game becomes predominantly influenced by skill rather than by chance. Their rationale is that chance elements cancel out in the long run while skill elements do not. Analyzing poker data from an empirical survey of 51,761 poker players, the authors conclude that: (a) low skill establishes itself much faster against the chance elements than high skill; (b) poker is in the continuum between being a game of chance and being a game of skill; and (c) for their sample, poker is a game of skill.

Using a game-theoretic approach to study the relative roles of skill and chance in games, Borm & van der Genugten (2001) conclude that the level of skill in the three popular variants of poker, Seven Card Stud, Texas Hold'Em, and Draw Poker, is greater than that in roulette, craps, and blackjack. Game theoretic modeling of poker can also be found in Ferguson & Ferguson (2007) and in the references cited therein.

Kelly, Dhar, & Verbiest (2007) examine the skill versus chance issue and its role in the debate on the legality of poker, observing that in a series of hands in a tournament, the individual draw of cards has a lower impact on the outcome than a single hand. They argue that in a tournament setting, the outcomes are subject to the law of large numbers and the differences in skill will be made apparent. Lipton, Lazarus, & Weber (2005) discuss games of skill versus games of chance in Canadian law. McCrory (2002) discusses legal issues surrounding the skill versus chance debate, particularly in the context of video poker, and notes the distinction between the 'English rule,' where any amount of skill is enough to qualify a game as a skill game and the 'American rule,' which states a game qualifies as a game of skill if skill is the dominant factor in the outcome of the game. In a series of papers, Heubeck (2008a, 2008b, 2008c) discusses the general issue of measuring skill in games in light of the fact that games offering prizes are often exempted from gambling statutes if the game exhibits sufficient skill.

Anecdotal Evidence

Many authors of popular books are experts in poker due to their extensive play, informal study, and intimate familiarity with the game (*e.g.*, Brunson, 2005; Carson, 2001; Krieger, 2000; Scarne, 1980; Sklansky, 1999). The consensus among these authors is that while the distribution of cards is random, the skill involved in betting predominates over chance. Scarne (1980) devotes an entire chapter in his book to the science and skill in poker. Referring to the proliferation of card games in nineteenth-century America, Sasuly (1982) observes that while some were purely games of chance, poker requires skill, judgment, and psychological strength. In discussing the issue of chance versus

Poker contains a greater skill element than any other card game, including contract bridge, pinochle, gin rummy, and blackjack.

skill in poker, many authors admit that chance can have an influence in the short term, but emphasize that skill has a more pronounced effect in the long run (Brisman, 1999; Levinson, 1963; Nestor, 2003). Others discuss the skill required in poker to that of other games, concluding that poker contains a greater skill element than any other card game, including contract bridge, pinochle, gin rummy, and blackjack (Scarne, 1980; Nestor, 1999). Commenting on the ability to consistently make money playing poker, one expert notes that there are a few professionals who earn a living playing blackjack and video poker, and though skill has a part in these games, luck and the percentages still hold the greatest sway. It's the other way around in poker; bad luck can hurt, but skill always beats luck over time (Nestor, 1999).

Success in poker relates to winning the most money and a mistake often made by novice and unskilled players is to try to win the most pots. As Krieger (2000) observes, a quick way to go broke is to play every hand; you'll win more pots along your personal road to ruin but the objective is to win the most money, not the most pots. Over the long run everybody gets the same proportion of good and bad cards; beginning poker players rely on big hands and lucky draws while expert players use their skills to minimize their losses on their bad hands and maximize their profits on their big hands (Sklansky, 1999). A skillful poker player can use position, psychology, bluffing, and other methods to increase his chances to win the pot and increase the size of the pots he wins (Carson, 2001).

Success in poker relates to winning the most money and a mistake often made by novice and unskilled players is to try to win the most pots.

Experts often cite several components to the skill necessary to play poker well. These include mathematics, psychology, deceptiveness, bluffing, assessing competition, reading hands, recognizing tells, exploiting position, and money management (Brunson, 2005; Scarne, 1980; Sklansky, 1999). In his classic book on the theory of gambling, Richard Epstein notes that poker games have a large number of strategic alternatives, and certain types are almost purely strategic (Epstein, 1995). There are numerous books devoted to the science and mathematics of poker (*e.g.*, Chen & Ankenman, 2006; Hilger, 2006; Mahmood, 2003); similarly, several address the psychology of poker (*e.g.*, Hilger & Taylor, 2007; Schoonmaker, 2000; Schoonmaker, 2007).

The collective expert opinion is clear – skill plays a large role in determining outcome in poker. As Sklansky (1999) summarizes, poker is not primarily a game of luck; it is a game of skill. The following section explores the difference between games of chance and games of skill.

Games of Chance versus Games of Skill

Gambling games can be categorized as those of pure chance and those involving an element of skill (Hannum & Cabot, 2005). In games of pure chance, outcome is determined by chance alone and no decision, strategy, or skill can be used by the player to affect the outcome, expectation, or percentage of money won (or lost). Games of pure chance include roulette, craps, keno, bingo, (traditional) slots, and lotteries. In games involving skill, typically decisions and strategies can affect the outcome and the percentage of money won or lost is a direct reflection of the player's level of skill. Among games involving skill, a further distinction can be made between house banked games of skill and player versus player (non-house banked) games of skill. In the former, a player can exercise skill to alter the house advantage and the latter the exercise of skill may result in a true player advantage. House banked games of skill include blackjack, video poker, and many of the newer poker-based casino games such as Caribbean Stud Poker, Let It Ride Poker, and Three Card Poker. These games are essentially a match between the player's skill and the rules of the game – the house uses a fixed strategy with no application of skill – and proper exercise of skill can reduce the house advantage. In house banked games of skill, it is often the case that an optimal strategy is known

and fairly easily mastered. Examples of player versus player games of skill are bridge, backgammon, chess, mahjong, and poker. In these games a player uses his or her skills against the skills of the other player(s) and the more skilled player will win over the less skilled player over time. In player versus player games of skill, optimal strategy is typically difficult to master and the motivated player is always learning strategies for winning. With this group of skill games the (motivated) player never stops learning and continues to learn new strategies for winning.

Some games may be categorized as pure skill, devoid of all probabilistic elements. Currently such games are not typically offered in a casino environment, but would include Tic-Tac-Toe, Checkers, Chess, and Go, among others (Epstein, p. 337).

The following section more carefully examines the roles of skill and chance in poker.

Poker, Skill, and Chance

Player versus player poker (herein referred to 'multiplayer poker' or simply 'poker') differs in substantial respect from the various activities often classified as gambling, such as lotteries and most casino-style games including video poker, because poker has many elements of skill not present in traditional games of chance. Video poker is a house-banked game with a fixed hold percentage at optimal play whereas multiplayer poker is an interactive, non-house banked game that allows individuals to compete with one another, where success is based on the application of a player's skills against other players. Such skills include mathematics (calculating odds), psychology, assessing competition, reading hands, recognizing tells, bluffing, folding, exploiting position, and money management. Whereas practice can improve the player's level of skill in player versus player poker, no amount of 'practice' will remove the house advantage in roulette, keno, or house-favorable video poker.

In pure games of chance, intentional 'bad play' cannot cause a player to lose, or lose faster. In games of skill, on the other hand, it is possible for a player to play badly, whether intentionally or not, and lose more. In particular, a skilled player in a player versus player game of skill could use his skill to intentionally lose faster than an unskilled player. This is the case for poker, but not for games of chance such as roulette, keno, or slots where it is not possible for a player to purposely lose, or lose faster. The ability to intentionally lose is a feature of games involving skill.

In a game of skill the player can alter the expected outcome; not so for a game of pure chance. The outcome of a bet in roulette, for example, is determined solely by chance. If a player bets on a single number in American roulette (where there is a double zero on the wheel), the probability of winning is 1/38 while the probability of losing 37/38. The payout however, is only 35-to-1. Thus, short of a biased wheel or cheating, there is nothing the player can do to change these probabilities or the expectation, which is –5.3 percent (i.e., the house edge is 5.3 percent). Similarly, a player betting at double-zero roulette will lose on average 5.3 percent of the money wagered, regardless of the particular bets made and the 'pattern' of betting. Because the spins of the roulette wheel are independent trials and the probabilities of winning and losing remain constant from trial to trial (and the expectation is negative on each trial), it is mathematically impossible to devise a system to change the expected win (loss) percentage. A novice roulette player will fare just as well (or poorly) as an 'experienced' roulette player; a player making random decisions in roulette will fare just as well or poorly as one who makes decisions according any sort of so-called strategy. In short, there is no such thing as a 'good' (or 'bad') roulette player.

In a game of skill the player can alter the expected outcome; not so for a game of pure chance.

The expected win in poker, on the other hand, depends on the skill or strategy employed by the player. In poker, certain knowledge can be brought to bear on the decisions made during the game, resulting in a greater expected win. While there are

arguably various facets of 'skill' in poker, the combinations of these facets are expressed through one element, betting – the decision on how much money (if any) to invest. Betting strategy in poker – whether to fold or bet and how much to bet – is a decision made of a player's own free will and is something at which a player can become skillful. A player's betting methods can get better or worse.

In poker games, if more than one player remains after the last round of betting, remaining players expose and compare their hands to determine the winner or winners. This is called the showdown. For hands that do not go to showdown, betting strategy, specifically one player's decision to invest in the hand while all others decide to not invest in the hand, is the sole factor in determining outcome; the winner is the one player left who has not folded. For hands that go to showdown, the betting strategy of folding determines the outcome if a player who folded had a better hand than the winner, since the winner would have been different had this player not folded. Hope, Mizelle, & McCulloch (2009) examined 103 million hands of Texas Hold'Em played at an online poker site and estimate that 76 percent of the hands in Texas Hold'Em do not go to showdown. Of the remaining 24 percent, only about half, or 12 percent of all hands, are won by the player at the table who would have had the best hand. This is because the player with the luckiest cards that would otherwise have been the best 5-card hand folded prior to showdown. Thus, only about 12 percent of the time does the player with the best or luckiest cards show his hand and win.

In a game involving skill, the smaller the difference in skill levels between players, or the shorter the duration of the contest (the 'short term'), the more uncertain is the outcome. Even for games in which skill is a predominant factor, when the gap in skill levels is small the results tend to resemble chance. This does not mean, however, that skill is not an important factor, but rather that it is more difficult to detect and assess the impact of skill when the relative skill levels of competing players are close. Consider, for example, the game of chess (or perhaps tennis, or golf), universally considered a game of skill. When the gap in skill levels between two chess players is large, the highly skilled player will consistently beat the less skilled player. However, when the gap in skill levels is small and the chess players are closely matched in levels of skill, the results may appear to be due to chance.

Most states use the 'predominance test' – if the element of skill in a particular game predominates over chance, then the game is permitted.

Regardless of the particular skill or combination of skills, what differentiates a game of skill and a game of chance is the ability of the player to influence the game's expectation, broadly defined as the expected outcome, through knowledge, judgment, decisions, and/or performance.

What constitutes skill or chance legally is subject to the differing interpretations of the federal government and state governments. Most states use the 'predominance test' – if the element of skill in a particular game predominates over chance, then the game is permitted (*see, e.g.*, Alexander, 2008; Cabot & Csoka, 2007; Humphrey, 2007b). Under this test, an activity is considered illegal gambling if a person risks something of value on an activity predominately determined by chance for the opportunity to win something of greater value than he or she risked. Most states have a common definition of the predominance test. Under the predominance test, one must envision a continuum with pure skill on one end and pure chance on the other. The element of chance is met if chance predominates over skill in determining the outcome of the contest, even if the activity requires some skill. In theory, an activity crosses from skill to chance exactly in the middle of the continuum. On the continuum, games such as chess would be at the skill end, while traditional slot machines would be at the chance end. Between these ends, there are many games that contain both skill and chance. In this area, a legal risk exists because it is a subjective assessment as to where on the continuum a game that is part skill and part chance lies.

Unfortunately, the predominance test is not the only test that courts employ in the various states. For example, in some states a game is prohibited if chance is a material element in the outcome. This is a lesser standard than the predominance test and effectively makes offering lawful skill-based gaming to residents of those states more difficult if the games in question resort to a chance component in determining the outcome. Yet, in some states skill or chance is irrelevant and merely wagering on any event or contest is sufficient to be illegal gambling (Hannum & Cabot, 2005; Humphrey, 2007a, 2007b).

While the type of skill that can be applied and the extent to which it may affect the outcome varies, if skill predominates over chance in determining the outcome of a game, it is usually considered a game of skill. This paper argues that in poker games such as Texas Hold'Em, while there are arguably various facets of 'skill,' the combinations of these facets are expressed through one element, namely, betting, and that this skill is the most likely factor influencing the outcome. The following section examines the skill versus chance issue in poker by analyzing the results of a one-on-one game of Texas Hold'Em in which a player making haphazard decisions plays against a (skilled) player who employs a winning strategy.

Analyzing Skill in Poker (Part A)

Scenario 1: Random versus Skilled Player

In poker, players compete against each other and money won or lost is merely transferred from one player to another (except for the house 'rake,' a small percentage taken from each pot, if any). This is true even in a casino, where cardroom poker differs from other house-banked games in that players are not playing against the house. The casino provides a dealer, who does not play, and makes money by taking a percentage of each pot, charging an hourly fee, or collecting a flat amount for every hand. The following section outlines the rules and terminology of Texas Hold'Em.

Texas Hold'Em

The most popular type of poker played today is Texas Hold'Em. The game typically accommodates between two and ten players. In the initial deal, each player is dealt two cards face down (the 'hole cards'). These cards are unique to the player to whom they were dealt. A round of betting then takes place. During each round of betting, a player can either start the betting (except the first round, where the betting has already been started with the forced 'blind' bets prior to any cards being dealt), call the bet coming to him, raise the betting, or fold his cards. In all betting rounds except the first, a player may check if no bet has yet been made on that round. If a player folds that player is removed from that hand. If the number of players is reduced to a single player, then that player wins regardless of his or her hand. After the first round of betting, three shared cards (the 'flop') are placed face up in the middle of the table. Another round of betting then takes place. Next, a single shared card (the 'turn') is turned up among the community cards in the center of the table, followed by a third round of betting. Finally, the last shared card (the 'river') is then added to the shared community cards, and a final round of betting occurs. At that point, if two or more players are still active, the person with the highest hand wins (the 'showdown'). The next section provides the background for the 'Random versus Skilled' game to be analysed.

Random versus Skilled – Background and Game Parameters

To shed light on the question of whether skill predominates over chance in poker, this study considered a two-player (heads-up) limit game of Texas Hold'Em in which an unskilled player making betting decisions haphazardly plays against a player employing a non-random betting strategy. The former player is referred to as 'Random,' and the latter as 'Skilled.' The logic behind analyzing this scenario is that if skill plays no part in poker,

then a player making random betting decisions should fare as well as any other player. If skill plays a role, there should be a strategy that can be employed to defeat the player making random decisions; the more convincing the defeat, the larger the role of skill. By comparing the performances of a player with no skill (Random) and a player employing a non-random strategy (Skilled), the impact of skill in this scenario can be assessed in terms of percentage of hands and (more importantly) amount of money won.

Against an opponent with no skill whatsoever and making decisions randomly a relatively simple strategy can be devised to win convincingly: Always raise the bet when permitted to do so and to call the bet otherwise. This will be the strategy employed by Skilled in this study. (When the gap in skill levels is not large, for example when one player is moderately skilled and the other very skilled, more complicated strategies would be necessary to defeat the opponent.) This analysis considers a $2/$4 limit heads-up game of Texas Hold'Em between the unskilled Random player (making betting decisions randomly) and the Skilled player (raise when possible, otherwise call), assuming a four-raise per round maximum. There is no house rake. The following section provides the mathematical results of this Random versus Skilled Texas Hold'Em game.

Random versus Skilled – Mathematical Analysis

Exact probabilities and win rates for this Skilled versus Random player Texas Hold'Em game can be derived mathematically using a decision tree approach. For purposes of this mathematical analysis it is assumed that each player wins half the showdowns (the issue of tied hands is addressed in the simulations section below). The analysis requires consideration of two cases, when Random is the small blind (Case 1) and when Skilled is the small blind (Case 2). A summary of the results of the mathematical analysis follows; further details showing probability calculations for each possible decision path for each case and an example tree diagram for the flop decisions in Case 1 are given in the Appendix.

Case 1: Small Blind = Random; Big Blind = Skilled.

Table 1 shows the exact probabilities of a hand making it to each stage of the game – flop, turn, river, and showdown – as well as exact win rates for each player for the case when Random is the small blind and Skilled is the big blind. Thus, 35.2 percent of the hands will make it to the flop (the other 64.8 percent of the time Random will fold pre-flop), 17.6 percent of all hands will make it to the turn (50 percent of those making it to the flop), 8.8 percent to the river (50 percent of those making it to the turn), and 4.4 percent to the showdown (50 percent of those making it to the river). Assuming showdown hands are divided equally, Skilled wins 97.8 percent and Random wins 2.2 percent of the hands.

Table 1. Probabilities and Win Rates – Random is Small Blind

Stage	*Probability*	*Win Rate – Skilled Player*	*Win Rate – Random Player*
Pre-Flop	-	.648148	-
Flop	.351852	.175926	-
Turn	.175926	.087963	-
River	.087963	.043981	-
Showdown*	.043981	.021991	.021991
OVERALL		.978009	.021991

** Assuming each player wins half the showdowns.*

Case 2: Small Blind = Skilled Player; Big Blind = Random Player.

Table 2 shows the exact probabilities of a hand making it to each stage of the game – flop, turn, river, and showdown – as well as exact win rates for each player for the case

when Skilled is the small blind and Random is the big blind. Note that the overall win rate for Skilled is slightly lower for this case (95.9 percent compared to 97.8 percent when Random is the small blind, assuming showdown hands are divided equally) due to the fact that almost twice as many hands make it to showdown (8.2 percent when Skilled is the small blind versus 4.4 percent when Random is the small blind). Put another way, fewer hands are folded by Random when Skilled is the small blind.

Table 2. Probabilities and Win Rates – Skilled is Small Blind

Stage	*Probability*	*Win Rate – Skilled Player*	*Win Rate – Random Player*
Pre-Flop	-	.444444	-
Flop	.555556	.262346	-
Turn	.293210	.138460	-
River	.154750	.073076	-
Showdown*	.081673	.040837	.040837
OVERALL		.959163	.040837

* *Assuming each player wins half the showdowns.*

Overall: Cases 1 and 2 Combined.

Table 3 shows the probabilities of a hand making it to each stage as well as win rates for each player when Cases 1 and 2 are combined (i.e., half the hands are played under each case). The results show that 45.4 percent of the hands will make it to the flop (the other 54.6 percent will be folded pre-flop by Random), slightly more than half of these will progress to the turn (so 23.5 percent of all hands will make it to the turn), slightly more than half of the turn hands will move on to the river (12.1 percent of all hands make it to the river), and slightly more than half the river hands will go to showdown (6.3 percent of all hands will go to showdown). Assuming each player wins half the showdown hands the overall win rates are 96.86 percent for Skilled and 3.14 percent for Random.

Table 3. Probabilities and Win Rates – Overall

Stage	*Probability*	*Win Rate – Skilled Player*	*Win Rate – Random Player*
Pre-Flop	-	.546296	-
Flop	.453704	.219136	-
Turn	.234568	.113212	-
River	.121356	.058529	-
Showdown*	.062827	.031414	.031414
OVERALL		.968586	.031414

* *Assuming each player wins half the showdowns.*

In the section below, large scale simulations were used to obtain an estimate of the percentage of ties in the Random versus Skilled scenario and validate the analytical results above.

Random versus Skilled – Simulation Analysis

Simulations of one billion hands each were conducted (implemented using a C++ program) for the Random versus Skilled Texas Hold'Em game described above. In

order to compare the simulation results with the mathematical analysis presented in the previous section, the first simulations were conducted without evaluating and comparing hands at showdown, assuming instead (as was done in the analytical analysis) that half the showdowns are won by each of the two players. In the second simulation, hands were evaluated and compared at showdown, allowing for an estimate of the percentage of ties.

Table 4 shows the results of one billion simulated hands when the players' hands are not compared at showdown. The results reveal that Skilled won 96.86 percent of the hands and $6.44 billion, or an average of 1.6 big blinds per hand. Random won 3.14 percent of the hands and lost $6.44 billion. Since showdown hands are not evaluated (it is assumed each player wins half the showdowns) there are no ties. These results are consistent with and confirm the analytical analysis and Table 3 final figures presented above.

Table 4. One Billion Hands Played – No Hand Evaluator*

Player	# Won	# Folded	$ Won/Lost
Random	31,412,489	937,176,985	-6,439,579,675
Skilled	968,587,511	0	+6,439,579,675
Ties	0		
Total Hands	1,000,000,000		

** Assuming each player wins half the showdowns.*

Table 5 shows the results of one billion simulated hands when the players' hands are compared at showdown, allowing for ties. In this second simulation, Skilled won 96.76 percent of the hands outright, Random won 3.04 percent outright, and 0.205 percent of the hands were ties (split pots). Note that these results are consistent with those of the no-hand-evaluation simulation in the sense that had the 62,833,476 (from 1,000,000,000 – 937,166,524) showdown hands been evenly divided between the two players, the resulting percentages of hands won by Skilled and Random would be 96.86 percent and 3.14 percent, respectively, the same figures as were obtained in Table 4 (as well as those from the analytical results in Table 3). As was the case with the previous simulation, the overall win amount for Skilled is approximately $6.44 billion, or an average of 1.6 big blinds per hand.

Table 5. One Billion Hands Played – Hand Evaluator

Player	# Won	# Folded	$ Won/Lost
Random	30,390,261	937,166,524	-6,439,490,668
Skilled	967,556,925	0	+6,439,490,668
Ties	2,052,814		
Total Hands	1,000,000,000		

Random versus Skilled – Summary

When a skilled player employing a raise-when-possible strategy is up against a player making haphazard (random) decisions in a limit Texas Hold'Em game, the skilled

player wins full pots 96.8 percent of the time and split pots 0.21 percent of the time, with a win rate average of 1.6 big blinds per hand (for comparison, three big blinds per hour, or 0.10 big blinds per hand assuming 30 hands per hour, is considered reasonably good among top poker players). That a player can implement a strategy to defeat another player such a high percentage of the hands, with such a large win rate is strong evidence that skill predominates over chance in determining the outcome in poker. Since a player making random decisions would fare just as well as any other player in a game of pure chance (such as roulette), these figures for the Texas Hold'Em game analyzed here speak to the overwhelming dominance of the role of skill, expressed through betting strategy, in poker.

The following section presents (additional) simulations of full-table Texas Hold'Em and Seven Card Stud that further support the notion that skill is a predominant factor in poker.

Analyzing Skill in Poker (Part B)

Scenario 2: Full-Table Simulations

This section examines the role of skill in full-table poker games in which some players are skilled and others are not. Computer simulations of one million hands were run for several situations for the two most popular poker games, Texas Hold'Em and Seven Card Stud, using Wilson's *Turbo Texas Hold'Em* and *Turbo Seven Card Stud* software. Because the simulation programs allow for different player betting profiles to be loaded into the games, it is possible to see the effects, in terms of money won or lost, when unskilled players are playing against skilled players. If skill is a predominant factor, the unskilled players will tend to lose as the cards 'even out' and it will become apparent that the skilled players beat the unskilled players as more and more hands are dealt. Such an approach is viable with poker because player profiles can be designed and set to play at different levels of skill. (It is impossible, for example, to design a simulation of roulette in which the long-run winnings of players differed. This is because there is no skill in roulette; regardless of how a player places bets, or tries to employ any so-called 'system' or strategy, the long-run expected winnings in double-zero roulette will be a loss of 5.3 percent of the money wagered.) Hourly win rates are computed assuming 30 hands per hour. The next two sections detail the simulation results for Texas Hold'Em and Seven Card Stud, respectively.

Texas Hold'Em: $20/$40 betting structure.

Four cases were examined for a ten-player $20/$40 limit Texas Hold'Em game: (1) ten skilled players, (2) one unskilled player and nine skilled players, (3) nine unskilled players and one skilled player, and (4) five skilled and five unskilled players. The results are as follows.

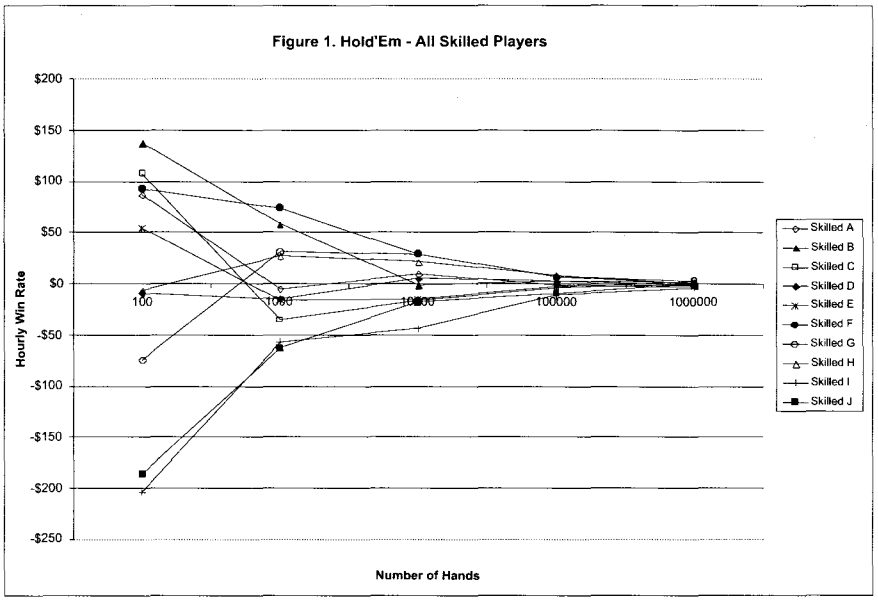


Figure 1 shows hourly win rate in a game with ten skilled players with identical player profiles. As expected due to the identical player profiles, differences among final win figures for the ten players were relatively small. The final win figures show that six players lost and four players won, with net wins ranging from -$132,047 to $116,400, or -$3.96 to $3.49 per hour.

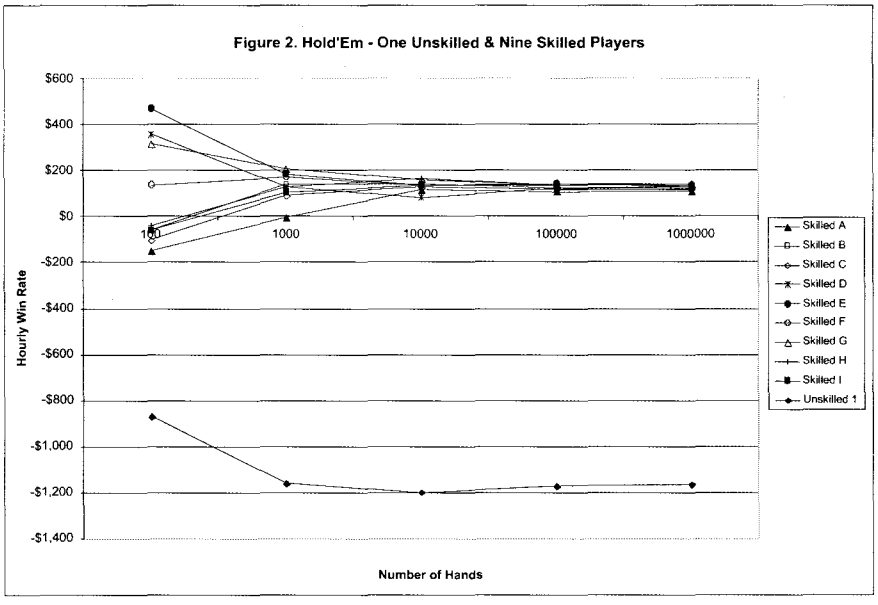


Figure 2 shows hourly win rate in a game with one unskilled player and nine skilled (identical profiles) players. The unskilled player lost approximately $38.8 million, compared to a win of roughly $4.3 million for each of the skilled players (win amounts for the skilled players ranged from $3.7 million to 4.7 million). This converts to an average hourly win rate of approximately $129 for the nine skilled players (range from $111 to $142) compared to an hourly loss of $1,165 for the unskilled player.

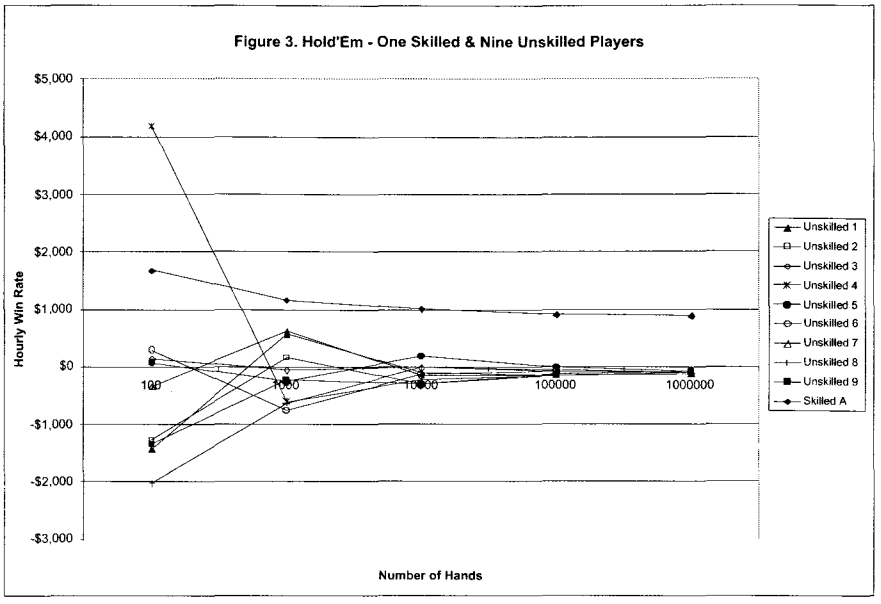


Figure 3 shows hourly win rate in a game with nine unskilled (identical profiles) players and one skilled player. Each of the unskilled players lost money – average loss was approximately $3.3 million (ranging from $2.4 million to $3.8 million), or almost $100 per hour ($71 to $114) – while the one skilled player won almost $30 million, or $880 per hour.

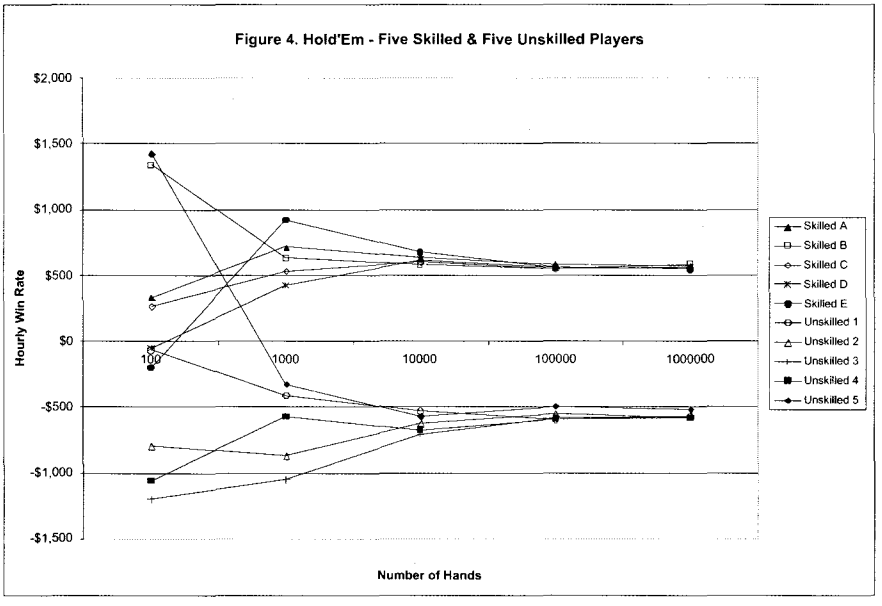


Figure 4 shows hourly win rate in a game with five unskilled (identical profiles) players and five skilled (identical profiles) players. The skilled players all won and the unskilled players all lost. Win amounts for the skilled players ranged from $18.2 million to $19.6 million (average $18.8 million), or $547 to $587 per hour (average hourly win $565). Losses for the five unskilled players ranged from $17.2 million to $19.4 million (average $18.8 million), or $517 to $583 per hour (average hourly loss $565).

Seven Card Stud: $6/$12 betting structure.

Four cases were examined for an eight-player $6/$12 limit Seven Card Stud game: (1) ten skilled players, (2) one unskilled player and nine skilled players, (3) nine unskilled players and one skilled player, and (4) five skilled and five unskilled players. The results are as follows.

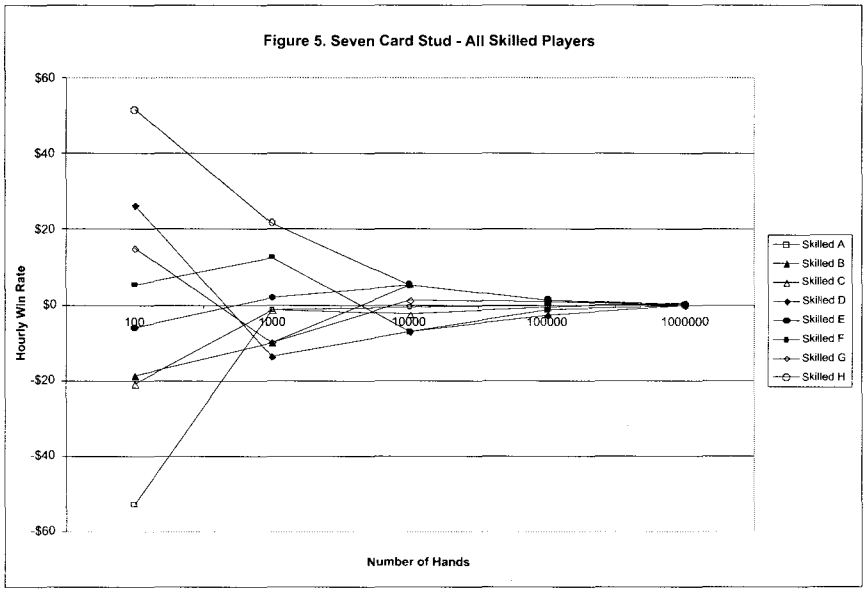


Figure 5 shows hourly win rate in a game with eight skilled players (all player profiles identical). As was the case for the analogous Hold'Em situation (where all player profiles were identical), differences among final win figures were relatively small. The final won/loss figures show that five players lost money and three players won, with net wins ranging from -$10,130 to $18,974, or -$0.30 to $0.57 per hour.

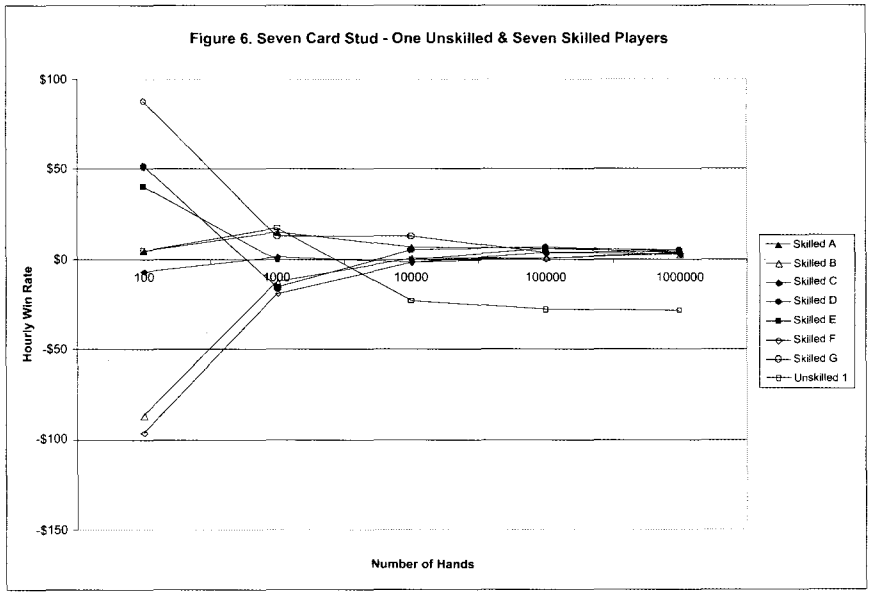


Figure 6 shows hourly win rate in a game with one unskilled player and seven skilled (identical profiles) players. The unskilled player lost $941,174 compared to an average win of $134,453 for the seven skilled players (ranging from $103,909 to $172,566). This converts to an average hourly win rate of $4.03 for the seven skilled players (from $3.12 to $5.18), compared to an hourly loss of $28.24 for the unskilled player.

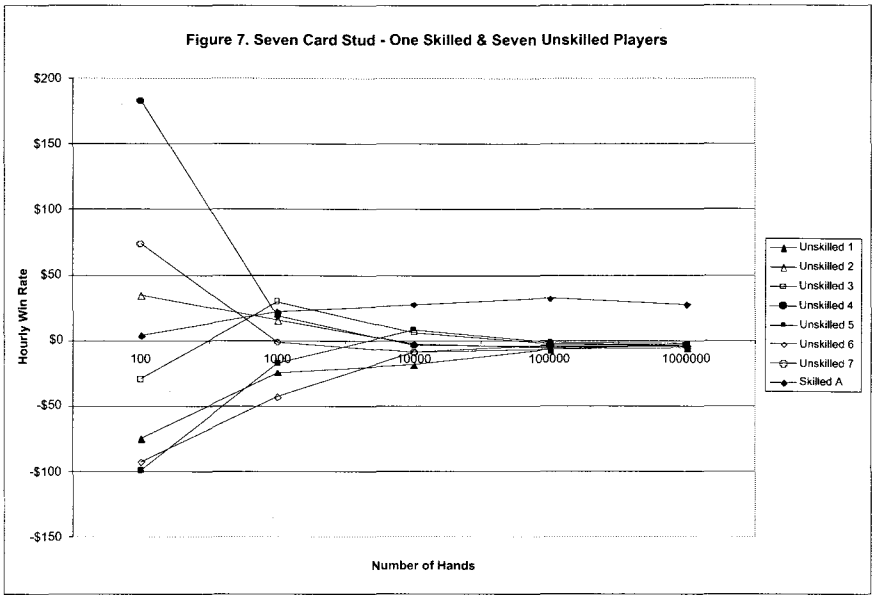


Figure 7 shows hourly win rate in a game with seven unskilled (identical profiles) players and one skilled player. Each of the unskilled players lost money – average loss was $130,017 (ranging from $94,242 to $192,203), or $3.90 per hour ($2.83 to $5.77) – while the one skilled player won nearly $910,117, or $27.30 per hour.

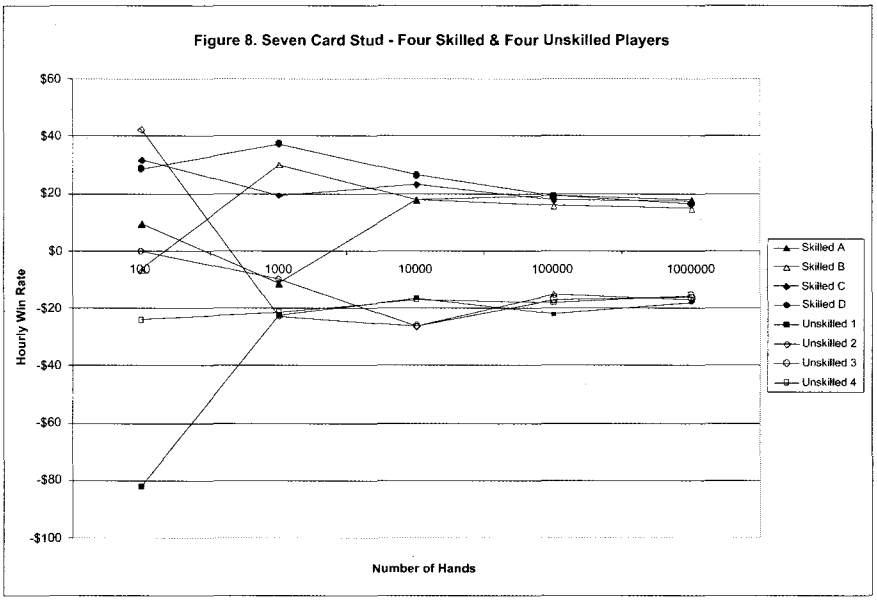


Figure 8 shows hourly win rate in a game with four unskilled (identical profiles) players and four skilled (identical profiles) players. In this case the skilled players all won and the unskilled players all lost. Win amounts for the skilled players ranged from $500,013 to $601,762 (average $556,080), or $15.00 to $18.05 per hour (average hourly win $16.68). Losses for the five unskilled players ranged from $515,633 to $594,786 (average $556,080), or $15.47 to $17.84 per hour (average hourly loss $16.68).

Summary of Full-Table Simulations

The results of these full-table simulations of Texas Hold'Em and Seven Card Stud games strongly suggest that the money in poker shifts from the weaker players to the more skilled players, and that over time a skilled player will beat an unskilled player.

Conclusions and Repercussions

The analysis and results presented in this paper suggest that poker is a game of predominantly skill, the skill elements expressed through the player's betting strategy; i.e., the decisions on whether to check, bet, call, raise, or fold. The importance of this factual decision can not be understated from a policy perspective because the very legality of poker hinges on the conclusion. Though the studies here focused primarily on Texas Hold'Em, with some examination of Seven Card Stud, similar results would be expected for other forms of poker. Further research examining the question of skill versus chance for different variants of poker and game scenarios is needed, but the evidence presented here suggests strongly that poker is a game of predominantly skill.

The ramifications to the traditional gaming industry if poker is determined to be a game of skill relate mostly to the close relationship between the poker industry and the casino industry. Many states that allow casinos also permit poker, including New Jersey, Nevada, Mississippi and Michigan. Likewise, some states without traditional land-based casinos also permit some forms of poker, including California and Florida. This broader appeal of poker together with its increased exposure over television and the Internet has made the casinos relevant to a broader base of patrons. For example, the number of players competing in the World Series of Poker (WSOP), held each year in Las Vegas at the Rio Hotel, rose exponentially for the first 35 years, from six players in the first main event to nearly 9,000, each of whom paid a buy-in of $10,000, in 2006 (PokerCasinoGuide.com). The tournament itself is fed by satellite tournaments held across the world in both casino and non-casino environments.

The effect of the expansion of poker on the Internet, television and other non-casino locations has had a direct impact on the casinos. As one *Los Angeles Times* reporter noted in May 2007:

> Poker has never been bigger in Vegas than right now. It was almost extinct five years ago, but there are now more than 100 poker rooms in Sin City, and probably two or three new ones added each month. The boom reflects the national poker craze touched off in 2003 by the Travel channel's World Poker Tour, which popularized the use of the "pocket cam," the hidden camera that lets the audience see the hole cards of each player. Overnight, one of the most boring activities to watch on TV became high drama. Throw in the no-limit betting rule in Texas Hold 'Em and you have nothing less than sweet music to Vegas casinos. (Cooper, 2007)

The value of the expansion of poker opportunities does not simply mean expansion of the existing poker rooms. It also brings a new demographic of player to the traditional casino. Poker players tend to be younger than the average casino patron and represent the generation that the casinos need to remain viable. Moreover, when Harrah's surveyed the players at the 2004 WSOP, it discovered that more than half of World Series of Poker players enjoy playing other table games and about a quarter also play slots and place bets in the sports book (Profile of the American Casino Gambler: Harrah's Survey 2004).

The determination that poker is a skill game will open new markets, both potentially land-based and on the Internet. Creating new growth and demand for the product will increase the demand for increased poker capacity in the traditional casinos, help solidify the popularity of major tournaments like the WSOP and the United States Poker Championship at Trump Taj Mahal in Atlantic City and bring an entire new demographic to the casinos where table games and slot machines can be cross-marketed.

Appendix

Decision Trees and Probabilities for Skilled versus Random

Case I: Random (*R*) = Small Blind; Skilled (*S*) = Big Blind

	Player							Player						
PRE-FLOP	*R*	*S*	*R*	*S*	*R*	*S*	Outcome	*R*	*S*	*R*	*S*	*R*	*S*	Probability
1	C	R1	C	X	X	X	Flop	0.3333	1	0.3333	X	X	X	0.111111
2	C	R1	F	X	X	X	S Wins	0.3333	1	0.3333	X	X	X	0.111111
3	C	R1	R2	R3	C	X	Flop	0.3333	1	0.3333	1	0.3333	X	0.037037
4	C	R1	R2	R3	F	X	S Wins	0.3333	1	0.3333	1	0.3333	X	0.037037
5	C	R1	R2	R3	R4	C	Flop	0.3333	1	0.3333	1	0.3333	1	0.037037
6	F	X	X	X	X	X	S Wins	0.3333	X	X	X	X	X	0.333333
7	R1	R2	C	X	X	X	Flop	0.3333	1	0.3333	X	X	X	0.111111
8	R1	R2	F	X	X	X	S Wins	0.3333	1	0.3333	X	X	X	0.111111
9	R1	R2	R3	R4	C	X	Flop	0.3333	1	0.3333	1	0.5000	X	0.055556
10	R1	R2	R3	R4	F	X	S Wins	0.3333	1	0.3333	1	0.5000	X	0.055556

	Player							Player						
FLOP	*S*	*R*	*S*	*R*	*S*	*R*	Outcome	*S*	*R*	*S*	*R*	*S*	*R*	Probability
1	Bet	C	X	X	X	X	Turn	1	0.3333	X	X	X	X	0.333333
2	Bet	F	X	X	X	X	S Wins	1	0.3333	X	X	X	X	0.333333
3	Bet	R1	R2	C	X	X	Turn	1	0.3333	1	0.33333	X	X	0.111111
4	Bet	R1	R2	F	X	X	S Wins	1	0.3333	1	0.33333	X	X	0.111111
5	Bet	R1	R2	R3	R4	C	Turn	1	0.3333	1	0.33333	1	0.5000	0.055556
6	Bet	R1	R2	R3	R4	F	S Wins	1	0.3333	1	0.33333	1	0.5000	0.055556

	Player							Player						
TURN	*S*	*R*	*S*	*R*	*S*	*R*	Outcome	*S*	*R*	*S*	*R*	*S*	*R*	Probability
1	Bet	C	X	X	X	X	River	1	0.3333	X	X	X	X	0.333333
2	Bet	F	X	X	X	X	S Wins	1	0.3333	X	X	X	X	0.333333
3	Bet	R1	R2	C	X	X	River	1	0.3333	1	0.33333	X	X	0.111111
4	Bet	R1	R2	F	X	X	S Wins	1	0.3333	1	0.33333	X	X	0.111111
5	Bet	R1	R2	R3	R4	C	River	1	0.3333	1	0.33333	1	0.5000	0.055556
6	Bet	R1	R2	R3	R4	F	S Wins	1	0.3333	1	0.33333	1	0.5000	0.055556

	Player							Player						
RIVER	*S*	*R*	*S*	*R*	*S*	*R*	Outcome	*S*	*R*	*S*	*R*	*S*	*R*	Probability
1	Bet	C	X	X	X	X	Showdown	1	0.3333	X	X	X	X	0.333333
2	Bet	F	X	X	X	X	S Wins	1	0.3333	X	X	X	X	0.333333
3	Bet	R1	R2	C	X	X	Showdown	1	0.3333	1	0.33333	X	X	0.111111
4	Bet	R1	R2	F	X	X	S Wins	1	0.3333	1	0.33333	X	X	0.111111
5	Bet	R1	R2	R3	R4	C	Showdown	1	0.3333	1	0.33333	1	0.5000	0.055556
6	Bet	R1	R2	R3	R4	F	S Wins	1	0.3333	1	0.33333	1	0.5000	0.055556

Betting Legend:
C = Call
F = Fold
R1 = First Raise
R2 = Second Raise
R3 = Third Raise
R4 = Fourth Raise
X = No decision options

Skilled Wins Pre-Flop: 0.648148
Skilled Wins on Flop: 0.175926
Skilled Wins on Turn: 0.087963
Skilled Wins on River: 0.043981
Skilled Wins on Showdown: 0.021991
0.978009

Pre-Flop to Flop: 0.351852
Flop to Turn: 0.500000
Turn to River: 0.500000
River to Showdown: 0.500000
To Flop: 0.351852
To Turn: 0.175926
To River: 0.087963
To Showdown: 0.043981

RANDOM WINS: 0.021991
SKILLED WINS: 0.978009

Case II: Skilled (*S*) = Small Blind; Random (*R*) = Big Blind

	Player							
PRE-FLOP	*S*	*R*	*S*	*R*	*S*	*R*	*S*	Outcome
1	R1	C	X	X	X	X	X	Flop
2	R1	F	X	X	X	X	X	S Wins
3	R1	R2	R3	C	X	X	X	Flop
4	R1	R2	R3	F	X	X	X	S Wins
5	R1	R2	R3	R4	C	X	X	Flop

	Player							
S	*R*	*S*	*R*	*S*	*R*	*S*	Probability
1	0.3333	X	X	X	X	X	0.333333
1	0.3333	X	X	X	X	X	0.333333
1	0.3333	1	0.33333	X	X	X	0.111111
1	0.3333	1	0.33333	X	X	X	0.111111
1	0.3333	1	0.33333	1	X	X	0.111111

	Player							
FLOP	*R*	*S*	*R*	*S*	*R*	*S*	*R*	Outcome
1	•	Bet	C	X	X	X	X	Turn
2	•	Bet	F	X	X	X	X	S Wins
3	•	Bet	R1	R2	C	X	X	Turn
4	•	Bet	R1	R2	F	X	X	S Wins
5	•	Bet	R1	R2	R3	R4	C	Turn
6	•	Bet	R1	R2	R3	R4	F	S Wins
7	Bet	R1	C	X	X	X	X	Turn
8	Bet	R1	F	X	X	X	X	S Wins
9	Bet	R1	R2	R3	C	X	X	Turn
10	Bet	R1	R2	R3	F	X	X	S Wins
11	Bet	R1	R2	R3	R4	C	X	Turn

	Player							
R	*S*	*R*	*S*	*R*	*S*	*R*	Probability
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	1	0.5000	0.027778
0.5000	1	0.33333	1	0.33333	1	0.5000	0.027778
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	1	X	0.055556

	Player							
TURN	*R*	*S*	*R*	*S*	*R*	*S*	*R*	Outcome
1	•	Bet	C	X	X	X	X	River
2	•	Bet	F	X	X	X	X	S Wins
3	•	Bet	R1	R2	C	X	X	River
4	•	Bet	R1	R2	F	X	X	S Wins
5	•	Bet	R1	R2	R3	R4	C	River
6	•	Bet	R1	R2	R3	R4	F	S Wins
7	Bet	R1	C	X	X	X	X	River
8	Bet	R1	F	X	X	X	X	S Wins
9	Bet	R1	R2	R3	C	X	X	River
10	Bet	R1	R2	R3	F	X	X	S Wins
11	Bet	R1	R2	R3	R4	C	X	River

	Player							
R	*S*	*R*	*S*	*R*	*S*	*R*	Probability
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	1	0.5000	0.027778
0.5000	1	0.33333	1	0.33333	1	0.5000	0.027778
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	1	X	0.055556

	Player							
RIVER	*R*	*S*	*R*	*S*	*R*	*S*	*R*	Outcome
1	•	Bet	C	X	X	X	X	Showdown
2	•	Bet	F	X	X	X	X	S Wins
3	•	Bet	R1	R2	C	X	X	Showdown
4	•	Bet	R1	R2	F	X	X	S Wins
5	•	Bet	R1	R2	R3	R4	C	Showdown
6	•	Bet	R1	R2	R3	R4	F	S Wins
7	Bet	R1	C	X	X	X	X	Showdown
8	Bet	R1	F	X	X	X	X	S Wins
9	Bet	R1	R2	R3	C	X	X	Showdown
10	Bet	R1	R2	R3	F	X	X	S Wins
11	Bet	R1	R2	R3	R4	C	X	Showdown

	Player							
R	*S*	*R*	*S*	*R*	*S*	*R*	Probability
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	1	0.5000	0.027778
0.5000	1	0.33333	1	0.33333	1	0.5000	0.027778
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	X	X	X	X	0.166667
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	X	X	0.055556
0.5000	1	0.33333	1	0.33333	1	X	0.055556

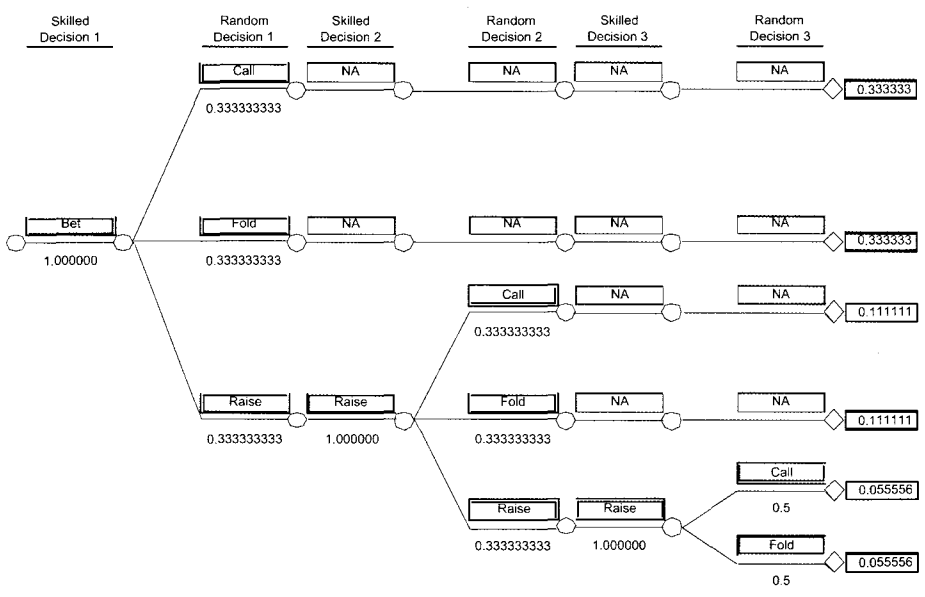
Betting Legend:
C = Call
F = Fold
R1 = First Raise
R2 = Second Raise
R3 = Third Raise
R4 = Fourth Raise
X = No decision options
• = Check

Skilled Wins Pre-Flop: 0.444444
Skilled Wins on Flop: 0.262346
Skilled Wins on Turn: 0.138460
Skilled Wins on River: 0.073076
Skilled Wins on Showdown: 0.040837
0.959163

Pre-Flop to Flop: 0.555556
Flop to Turn: 0.527778
Turn to River: 0.527778
River to Showdown: 0.527778
To Flop: 0.555556
To Turn: 0.293210
To River: 0.154750
To Showdown: 0.081673

RANDOM WINS: 0.040837
SKILLED WINS: 0.959163

Example Tree Analysis for Case 1, Flop



References

Alon, N. (2007). Poker, chance and skill. Available at http://www.cs.tau.ac.il/~nogaa/PDFS/skill4.pdf.

Alexander, G. (2008). The U.S. on tilt: Why the unlawful Internet gambling enforcement act is a bad bet. *Duke Law & Technology Review*, 5, Available at http://www.law.duke.edu/journals/dltr/articles/pdf/2008DLTR0006.pdf.

Borm, P., & van der Genugten, B. (2001). On a relative measure of skill for games with chance elements. *Trabajos de Investigacion Operativa* (TOP – Official Journal of the Spanish Society of Statistics and Operations Research), 9, 91-114.

Brisman, A. (1999). *American Mensa guide to casino gaming*. New York: Sterling.

Brunson, D. (2005). *Super system 2: A course in power poker.* New York: Cardoza.

Cabot A., & Csoka, L. (2004). The games people play: Is it time for a new legal approach to prize games? *Nevada Law Journal*, 4, 197-261.

Cabot, A., & Hannum, R. (2005). Poker: Public policy, law, mathematics and the future of an American tradition. *Thomas M. Cooley Law Review*, 22, 443-513.

Cabot A., & Csoka, L. (2007). Fantasy sports: One form of mainstream wagering in the United States. *John Marshall Law Review*, 40, 1195-1219.

Carson, G. (2001). *The complete book of Hold'Em poker*. New York: Kensington.

Chen, B., & Ankenman, J. (2006). *The mathematics of poker*. Pittsburgh, PA: ConJelCo.

Cooper, M. (2007). No-holds-barred poker. *Los Angeles Times*, May 27, L-6. Available at http://articles.latimes.com/2007/may/27/travel/tr-vegas27.

Croson, R., Fishman, P., & Pope, D. (2008). Poker superstars: Skill or luck? *Chance, 21(4), 25-28.*

Dedonno, M., & Detterman, D. (2008). Poker is a skill. *Gaming Law Review*, 12, 31-36.

Epstein, R. (1995). *The theory of gambling and statistical logic* (rev. ed.). San Diego: CA: Academic Press.

Ferguson, C., & Ferguson, T. (2007). The endgame in poker. In S.N. Ethier & W.R. Eadington (Eds.), *Optimal play: Mathematical studies of games and gambling* (pp. 79-106). Reno, NV: Institute for the Study of Gambling and Commercial Gaming, University of Nevada, Reno.

Fiedler, I., & Rock, J. (2009). Quantifying skill in games—Theory and empirical evidence for poker. *Gaming Law Review and Economics*, 13, 50-57.

Geller, S. (2009). Colorado jury agrees poker is game of skill. *Poker Listings*, January 27. Available at http://www.pokerlistings.com/colorado-jury-agrees-poker-is-game-of-skill-35444.

Hannum, R., & Cabot, A. (2005). *Practical casino math* (2nd ed.). Reno, NV: Institute for the Study of Gambling and Commercial Gaming, University of Nevada, Reno.

Heubeck, S. (2008a). Measuring skill in games: A critical review of methodologies. *Gaming Law Review and Economics*, 12, 231-238.

Heubeck, S. (2008b). Measuring skill in games with random payoffs: Evaluating legality. *Review of Law and Economics*, 4, 25-34.

Heubeck, S. (2008c). A short-run measure of relative skill in games. Unpublished paper.

Hilger, M., & Taylor, I. (2007). *The poker mindset: Essential attitudes for poker success.* Atlanta, GA: Dimat Enterprises.

Hilger, M. (2006). *Texas Hold'Em odds and probabilities.* Atlanta, GA: Dimat Enterprises.

Hope, P., Mizelle, B., & McCulloch, S. (2009). Statistical analysis of Texas Hold'Em. Report dated January 29, Cigital, Inc.

Humphrey, C. (2007a). Is U.S. online poker a game of skill? http://www.gambling-law-us.com/Articles-Notes/online-poker-skill.htm.

Humphrey, C. (2007b). State gambling law summary. http://www.gambling-law-us.com/State-Law-Summary/.

Jenkins, T. (2009). Colorado poker league organizer found not guilty. *Poker News Daily*, January 26. Available at http://www.pokernewsdaily.com/colorado-poker-league-organizer-found-not-guilty-969/.

Kadane, J. (1986). Does electronic draw poker require skill to play? In M. H. DeGroot, S. E. Fienberg, & J. B. Kadane (Eds.), *Statistics and the law* (pp. 333-343). New York: Wiley.
Kelly, J., Dhar, Z., & Verbiest, T. (2007). Poker and the law: Is it a game of skill or chance and legally does it matter? *Gaming Law Review*, 11, 190-202.
Krieger, L. (2000). *Hold'Em excellence: From beginner to winner*. Pittsburgh, PA: ConJelCo.
Kropf, S. (2009). Poker convictions appealed. *Charleston Post and Courier*, February 28. Available at http://www.charleston.net/news/2009/feb/28/poker_convictions_appealed73355/.
Larkey, P., Kadane, J., Austin, R., & Zamir, S. (1997). Skill in games. *Management Science*, 43, 596-609.
Levinson, H. (1963). *Chance, luck and statistics*. Mineola, NY: Dover.
Lipton, M., Lazarus, M., & Weber, K. (2005). Games of skill and chance in Canada. *Gaming Law Review*, 9, 10-18.
Mahmood, M. (2003). *The science of poker*. London: High Stakes Publishing.
McCrory, J. (2002). Video poker and the skill versus chance debate. *Gaming Law Review, 6*, 223-227.
Nestor, B. (1999). *The unofficial guide to casino gambling*. New York: Macmillan.
Nestor, B. (2003). *The smarter bet guide to poker*. New York: Sterling.
Newell, J. (2009). South Carolina finds poker a skill game but defendants guilty. *Bluff Magazine*, February 19. Available at http://news.bluffmagazine.com/south-carolina-finds-poker-a-skill-game-but-defendants-guilty-2407/.
PokerCasinoGuide.com (n.d.). WSOP history. Retrieved March 1, 2009, from http://www.pokercasinoguide.com/wsop/wsop.asp.
Polson, S. (2009). S. Carolina judge rules poker game of skill. *PokerListings*, February 19. Available at http://www.pokerlistings.com/s-carolina-judge-rules-poker-game-of-skill-37143.
Profile of the American Casino Gambler: Harrah's Survey 2004. Available at http://www.hotel-online.com/News/PR2004_4th/Oct04_HarrahsSurvey.html.
Rotstein, G. (2009). Legal status of poker: Is it a game of skill or chance? *Pittsburgh Post-Gazette*, March 1. Available at http://www.post-gazette.com/pg/09060/952256-455.stm.
Sasuly, R. (1982). *Bookies and bettors: Two hundred years of gambling*. New York: Holt, Rinehart & Winston.
Scarne, J. (1980). *Scarne's guide to modern poker*. New York: Simon and Schuster.
Schoonmaker, A. (2000). *The psychology of poker*. Henderson, NV: Two Plus Two Publishing.
Schoonmaker, A. (2007). *Your worst poker enemy*. New York: Lyle Stuart.
Sklansky, D. (1999). *The theory of poker*. Henderson, NV: Two Plus Two Publishing.
Ware, M., & Kadane, J. (2002). Chance and skill in games: Electronic draw poker. *Jurimetrics*, 43, 129-134.

Article submitted: 2/9/09
Sent to peer review: 2/16/09
Reviewer comments sent to author: 3/2/09
Author's revised version received: 3/10/09
Article accepted for publication: 3/10/09