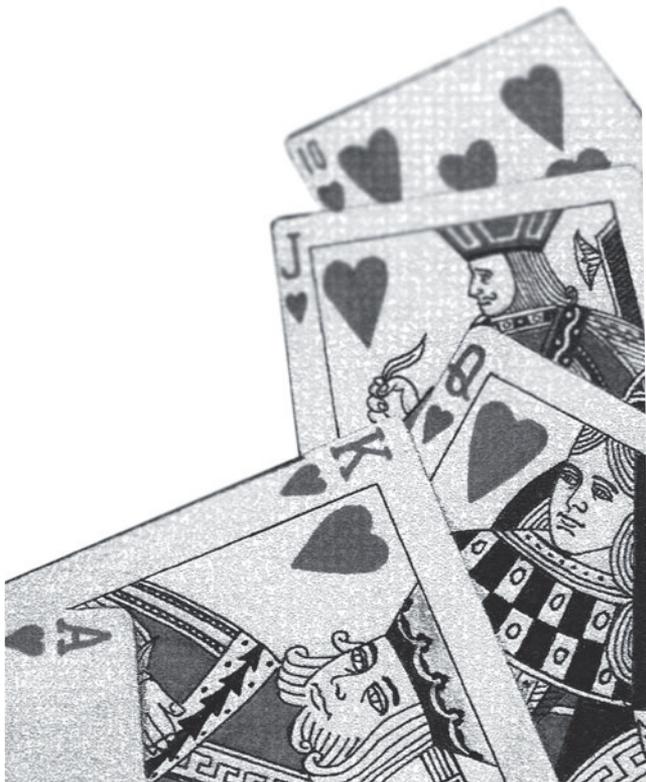


Best Hand Wins: How Poker Is Governed by Chance

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During the last several years, poker has grown in popularity so much that some might even say it's become a social phenomenon. Whereas poker was not played much by nonspecialists a few years ago, it has since democratized and become one of the most practiced card games.

Accordingly, the stereotype of the poker player has moved from the old guy who smokes a cigar and hides an ace in his sleeve to the 21 year old who plays online.

While the five-card draw used to be the most famous variant of poker, the variant widely practiced today is Texas hold 'em. In Texas hold 'em, each player is dealt two cards face down. This level is called preflop, and play begins with a first betting round in which each player can check (i.e., stay in the play without having to bet), bet, raise (i.e., bet over a bet), or fold (i.e., leave the play).

The dealer then deals a flop, three face-up community cards. The flop is followed by a second betting round. After the flop betting round ends, a single community card called the turn is dealt, followed by a third betting round. A final single community card called the river is then dealt, followed by a fourth betting round.

A play can be completed in two ways. First, at least two players have reached the river having bet the same amount. In this case, the remaining players reveal their hands and the winner is the one who holds the best hand (i.e., showdown).

Second, at one of the four levels of play, all players have folded their hands except one, who is then the winner. In such cases, the player who wins the pot does not have to reveal his cards (i.e., no showdown).

Because of the growth of poker's popularity and its economic importance, the issue of whether poker is governed by skill or chance has become recurring and turned into a social debate, as evidenced by Celeste Biever's recent paper in *The New Scientist*. As a card game, poker would be governed by chance if the outcome of most games were determined by the value of the cards—the distribution of the cards being random. In other words, the player who wins the pot would also be the one who holds the best hand in most cases.

Poker would be governed by skill if the outcome of most games were determined by something other than the value of the cards, such as the betting technique, reading of opponents, or psychology, all of which are grouped under the generic term "skill." The poker industry strongly promotes the idea that poker involves skill more than chance.

The purpose of our study was to provide new empirical evidence to this debate. This work was done in response to a recent study by Cigital, Inc., a consulting firm, that reported two major findings over 103 millions hands: that games did not end in a showdown 75.7% of the time and only 50.3% of those in the 24.3% of showdowns were won by the best hand. Both results suggest the outcome of games is determined by something other than the value of the cards. Thus, Cigital concluded that poker is governed by skill.

In our study, we show that this interpretation is not relevant when data are further analyzed. Moreover, our research applied inferential statistics, which allowed a clear test of the theoretical hypothesis that poker is governed by chance, while the Cigital research provided only descriptive statistics. Our findings provide clear statistical evidence corroborating this hypothesis.

Method

Data Acquisition

Given the nature of the analysis to be performed, we needed a database that met two criteria: it was relative to cash-game poker, rather than four-tournament poker, and it included the hands of all players in each game, even folded hands. Even though such data are difficult to obtain, they can be found in poker television programs. Two met our criteria: "High Stake Poker" (season five only) and "Poker After Dark" (season four, "Cash Game #1" and "Cash Game #2"; season five, "Nets vs. Vets Cash Game," "Hellmuth Bash Cash Game I," and "Hellmuth Bash Cash Game II"; season six, "Top Guns Cash Game #1" and "Top Guns Cash Game #2"). The coding of these programs resulted in a 678-game database.

Data Coding

For each game, 13 variables were coded for each hand, together with the two cards of each player and the cards on the board. "Showdown" indicates whether a given game ended in a showdown, whereas "Level" indicates the level reached in the game (i.e., preflop, flop, turn, river).

"Progress" indicates whether a hand was still in progress when the game ended. To illustrate this variable, let's consider a game in which two players were to the flop. One of the players bet; the other player folded. In this simple case, these two players were in progress when the game ended, while players who folded their hands before the flop were not in progress. There are more subtle cases, however, in which the coding of the progress variable is less obvious. For example, consider a game in which three players—A, B, and C—flop. A was the first player to act and he or she bet. Then B folded, C raised, and A folded. In this case, despite there being three players to flop, there were only two involved when the game ended. Indeed, B was no longer in progress when C raised, which resulted in A folding and the game ending.

"Status" indicates whether a hand was the best among the hands in progress when the game ended. "Result" indicates the objective outcome of a hand (i.e., won or lost).

The next four variables refer to which hand was the best at each level of the games among the hands of all players. For instance, for a game that reached the turn, we coded which hand was the best at the preflop, which hand was best at the flop, and which hand was best at the turn.

The last four variables refer to the strength of hands at each level of the games. The strength of a hand was defined as an ordinal variable with three levels: weak, marginal, and strong (see supplemental material at www.amstat.org/publications/chance/supplemental).

Contrary to classical poker databases, which allow computing of global statistics only (e.g., proportion of games won at showdown, proportion of games won at preflop), our database offered real possibilities for further analysis. Indeed, knowing the hand of each player and which hand was the best at each level of the games allowed us to probe the underlying mechanisms of poker.

Results

Three kinds of games were excluded from the analysis: games that ended in a slip pot (1.47%); those that did not end in a showdown, but in which players held the same hand (0.15%); and those in which the board was run more than one time (1.03%). This resulted in a 660-game sample.

We basically estimated the same three proportions as Cigital, Inc. Our estimations (and 95% confidence intervals) were:

73.5% (70.2,76.8) of games without showdown

15.3% (12.6,18.0) of games that ended in a showdown in which the best absolute hand did not win

11.2% (8.8,13.6) of games that ended in a showdown in which the best absolute hand won

Based on their 103-million hand sample, Cigital, Inc. reported 75.7%, 12.1%, and 12.2% for the first, second, and third proportions, respectively.

**“Phil Hellmuth said:
'Poker is 100% skill and
50% luck.' That quote is
100% dubious!”**

- Anonymous (Two Plus Two poker forum)

Although both sets of estimations are similar, the two samples differ slightly [$\chi^2 = 6.6$, $df = 2$, $p < .05$], especially regarding the proportion of games that ended in a showdown in which the best absolute hand did not win. This difference could be because Cigital's sample included hands played online by a majority of amateur poker players, whereas our sample included hands played live by professional poker players. Since professional players tend to bluff more than amateur players, it seems normal that best absolute hands won less often in the latter sample.

More fundamentally, we do not claim that our sample is representative of Texas hold 'em as a whole. Indeed, one should first define all the relevant features of the population to construct a representative sample of Texas hold 'em, and it seems Cigital did not. As a result, one cannot claim that Cigital's sample is more representative of Texas hold 'em than ours, because online poker played by amateurs is not more representative of Texas hold 'em than live poker played by professionals.

Games with Showdown

One of the arguments advanced by Cigital to support the hypothesis that poker involves skill more than chance is that the best hand wins only 50.3% of the time at showdown. At first glance, such a proportion seems surprising, as one would logically expect the best hand to win every time at showdown. Actually, this finding relies on a particular meaning of the "best hand."

In each game, while the best "absolute" hand is the one held by the player who would have made the best five-card hand at showdown, the best "relative" hand is the best hand among players who were in progress when the game ended. In the latter, the best hand is determined by taking into account all players, regardless of whether they folded. In the former, the best hand is determined with respect to players who were in progress when the game ended. Based on these considerations, it seems Cigital's finding relies on the notion of best absolute hand (i.e., best relative hand wins every time at showdown by definition).

To illustrate the difference between best absolute hand and best relative hand, let's consider the following example. Three players—A, B, and C—start a play. A holds the five of diamonds and five of spades (a pair of fives), B holds the ace of hearts and the king of spades (two high cards), and C holds the ace of clubs and the 10 of diamonds.

The flop is the ace of diamonds, the king of hearts, and the queen of clubs. The value of the hands is now a pair of

Table 1—Contingency Table of Best Absolute Hand Strength by Level at Time of Fold

Hand Strength	Level				Row total
	Preflop	Flop	Turn	River	
<i>Weak</i>					
Observed	78	3	0	0	81
Column %	97.5	33.3	0.0	0.0	(80.2%)
<i>Marginal</i>					
Observed	2	5	1	1	9
Column %	2.5	55.6	100.0	9.1	(8.9%)
<i>Strong</i>					
Observed	0	1	0	10	11
Column %	0.0	11.1	0.0	90.9	(10.9%)
Column total	80	9	1	11	101
	(79.2%)	(8.9%)	(1.0%)	(10.9%)	

fives for A, two pairs (aces and kings) for B, and a pair of aces for C. In terms of hand strength, B is better than C, which is better than A.

In the first betting round, A checks, B bets, C calls, and A folds. The card at the turn is the five of clubs. If A had remained in the game, A would have had the strongest hand (three fives). B bets and C calls. The card at the river is the two of hearts, which does not help any of the players. B bets and C calls, so the game ends in a showdown. B holds the best relative hand (top two pairs), whereas A holds the best absolute hand (three of a kind). In this play, the best relative hand (B) wins because A folded. Player C loses the most money.

Given that the best absolute hand does not win at showdown in half the cases, Cigital suggested that this hand was beaten by skill. This rationale is valid only under the assumption that the best absolute hand is the best hand at all levels of a game. Instead, if the best absolute hand is not the best hand from stem to stern in most cases, then this hand is dominated at a certain level in the play. Therefore, it could be that the best absolute hand does not win at showdown half the time because it is dominated before showdown half of the time.

To test this alternative interpretation, we analyzed the statistical properties of best absolute hands that did not win at showdown. Table 1 presents the contingency table of best absolute hand strength by level categories at time of fold.

Two main observations can be drawn from this table. First, best absolute hands that did not win at showdown were folded preflop 79% of the time. Second, even though these hands would have won at showdown, they were actually weak hands when they were folded (80% of the time). Moreover, regarding their status, these hands were inferior when they folded 82% of the time. Taken together, these

three observations lead to a clear conclusion: Best absolute hands that did not win at showdown were actually largely dominated when they were folded.

Accordingly, the best absolute hand does not win at showdown half the time because it was beaten before showdown half the time—not because it faced a skilled player who bluffed. In other words, it is the value of the cards in this set of games, rather than skill, that determines the outcome. Moreover, these findings highlight the importance of how the best hand is defined. We claim that when determining the best hand, only considering the best relative hand makes sense.

Games Without Showdown

The second argument advanced by Cigital is that games that do not end in a showdown are governed by skill, and that such a scenario occurs in the large majority of cases (75.7% of the time). At first glance, this argument makes sense. Indeed, a card game is considered to be governed by chance if the outcome of most games is directly related to the value of the cards. Therefore, one could conclude that games without showdown cannot be governed by chance, since no private card is revealed.

It is worth noting that games without showdown are the core of poker. In fact, the possibility of winning a game without having to reveal one's cards is poker's trademark. This feature seems to eliminate chance for the benefit of skill and opens the door to bluff.

Metaphorically, games without showdown are the kingdom of skill and the bluff is king. To illustrate this idea, let's consider the summary of a promotional video distributed by "Poker After Dark." The narrator is Doyle Brunson, a poker living legend. Here is what he says: "It all begins with a raise before the flop, then a re-raise. You fold, then a call. Jack,

Table 2—Contingency Table of Winning Hand Status by Level

Winning Hand Status	Level				Row total
	Preflop	Flop	Turn	River	
<i>Inferior</i>					
Observed	38	41	37	16	132
Column %	37.3	25.8	31.1	15.2	(27.2%)
<i>Best</i>					
Observed	64	118	82	89	353
Column %	62.7	74.2	68.9	84.8	(72.8%)
Column total	102	159	119	105	485
	(21.0%)	(32.8%)	(24.5%)	(21.6%)	

four, 10, with two hearts at the flop. Check, bet, and call. The Ace of heart[s] is the turn. Bet, and a big raise. Now the real game begins.”

Then, the other player folds his hand—a pair of aces—which was probably the best hand. The remaining player wins the pot without showing his cards. “That’s poker, folks,” says Brunson.

This promotional video shows what advocates of poker think to be the core of the game: When cards are not revealed, one can put the pressure on the player who holds the best hand and force him to fold. This reasoning is valid at an explicit level, but one also could consider an implicit level. Indeed, that cards are not revealed is not sufficient to discard their influence on the outcome. One has to consider the possibility that most games without showdown are nevertheless won by the player who actually holds the best hand.

We therefore analyzed games without showdown (485 games) in more detail. We tested the hypothesis that poker is governed by chance by examining the distribution of winning hands in those games. According to what we suggested previously regarding best hand determination, we considered best relative hands (i.e., the best hand among players who were in progress when the game ended), rather than best absolute hand (i.e., the best potential five-card hand that would have won when the game ended).

If poker is governed by skill, winning hands should be uniformly distributed into the inferior hand and best (relative) hand categories (i.e., null hypothesis). Indeed, claiming that poker is governed by skill means winning or losing with a particular hand does not depend on its objective value. In other words, one could win as much with inferior hands as with best hands.

However, if poker is governed by chance, winning hands would be best relative hands most of the time (i.e., alternative hypothesis). This means the outcome of a particular hand would be directly related to its objective value: one would win with best hands and lose with inferior hands.

A one-way chi-square test revealed that winning hands were best hands in most cases [$\chi^2 = 99.8$, $df = 1$, $p < .001$, after Yates’s correction]. Indeed, of the 485 winning hands, 353 were best hands, corresponding to 72.8% (69.5,76.1). Thus, even when hands were not revealed, best hand won almost 75% of the time.

Moreover, this tendency was observed at each level of the games. Though the dominance of best hands was slightly modulated by level, [$\chi^2 = 13.9$, $df = 3$, $p < .005$], the best hand tended to win whichever level was reached. Indeed, best hand won 62.7% (59.1,66.3) of the time at the preflop, 74.2% (70.9,77.5) of the time at the flop, 68.9% (65.4,72.4) of the time at the turn, and 84.8% (82.1,87.5) of the time at the river. Table 2 presents the contingency table of winning hand status by level categories. Considering the process of getting a winner as a process of survival with each level being a new obstacle, these findings show that the best existing hand tends to survive to the winning stage most of the time.

One could argue that winning hands being best hands almost 75% of the time does not demonstrate that poker is governed by chance. In fact, when hands are not revealed, holding the best hand is not sufficient to win. Holding the best hand is related to chance, but knowing that one holds the best hand is related to skill. However, knowing that one holds the best hand might not involve much skill, since it could be that best hands are strong hands in most cases. Indeed, the probability of holding the best hand is directly related to the strength of one’s hand, and there is no need to be a skilled



player to know that. Thus, we further tested the hypothesis that poker is governed by chance by analyzing the distribution of winning hands as a function of hand strength.

While the skill hypothesis states that winning hands should be uniformly distributed into the weak, marginal, and strong categories (i.e., one could win whatever the hand strength), the chance hypothesis assumes winning hands should be strong hands most of the time. A one-way chi-square test confirmed that winning hands were strong in most cases [$\chi^2 = 72.9$, $df = 2$, $p < .001$]. In fact, of the 485 winning hands, 27.0% (23.7,30.3) were weak, 21.6% (18.5,24.7) were marginal, and 51.3% (47.6,55.0) were strong. This supports our claim that knowing one holds the best hand does not require much skill, as winning hands are strong most of the time.

Conclusion

Our study might suffer from two limits. The first concerns our sample, which included games played by top professionals only. Since such players have relatively the same amount of skill, it could be that luck determines the outcome of games in such cases. It is more likely that skill would play a significant role when skilled players play against beginners. Further research is needed to investigate how properties of winning hands depend on the level of players.

The second limit is that our analysis did not take into account betting history. Betting influences the outcome of games along with the value of the cards. While we showed

that the latter plays a massive role in the process of getting a winner in each game, it seems likely that betting also plays a significant role. For instance, a weak hand is more likely to survive when accompanied by proper betting. In the same way, a strong hand is more likely to make money if the betting pattern is adequate. Betting could be used to measure the amount of skill with which a hand was played, so that one could determine which of the chance (i.e., the value of the cards) or skill (i.e., betting) factors best predicts the outcome of hands. This would address further the chance vs. skill issue and extend our findings. We plan to construct a database that includes betting history for the games.

When addressing the chance vs. skill issue, one should always keep two guidelines in mind. First, such an issue is unlikely to be resolved by a study alone. As a result, legal decisions regarding the status of poker should be made by examining all available scientific evidence.

Second, games of pure chance and games of pure skill are located at the extremities of a continuum, and poker is located at a certain point on this continuum. No one can deny that poker involves a certain degree of chance. The mere existence of "bad beats" (i.e., the favorite hand finally loses) is a direct consequence of this random component of the game. However, some studies reported that skill also plays a significant role.

For example, Rachel Croson, Peter Fishman, and Devin Pope showed that poker is similar to golf, which is a typical game of skill, in a recent *CHANCE* article. Moreover, Michael DeDonno and Douglas Detterman reported in an article published in the *Gaming Law Review* the findings of learning effects in poker. Such effects would not be observed if poker were a game of pure chance. As a result, poker is neither a game of pure chance nor a game of pure skill. Thence, the problem is to determine whether poker is dominated by chance or by skill.

By showing that it is the value of the cards that mostly determines the outcome, our findings demonstrate that poker is truly governed by chance. In most cases, the player who wins the pot is the one for whom the cards were the most favorable. Best hand wins with and without showdown. That's poker, folks. ♣

Further Reading

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