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COMPARATIVE STRATEGIES FOR PROFESSIONAL AND AMATEUR POKER PLAYERS

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Abstract

What makes professional poker players different from amateur poker players? The essence of the game of poker makes this question somewhat problematic to answer. In other competitive games what separates professionals and amateurs is more apparent. For example in the sports of sprinting or weightlifting professionals outperform amateurs by being faster or stronger. But poker and other games like it are based on information. This analysis investigates the differences in strategies between professional and amateur poker players by empirically investigating how these individuals value information.

The analysis has attempted to answer questions concerning how poker players make decisions and how these decisions differ for different levels of poker players. The analysis has shown that information that is revealed within the game is what players are using in order to form strategies and make decisions. Furthermore this analysis has shown that professionals are more encompassing with their decisions. That is when professionals are making decisions they are able to better use the information within the game relative to amateurs.

Key words: No Limit Texas Hold'em, Comparative Strategies

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I. Introduction

What makes professional poker players different from amateur poker players? The essence of the game of poker makes this question somewhat problematic to answer. In other competitive games what separates professionals and amateurs is more apparent. For example in the sports of sprinting or weightlifting professionals outperform amateurs by being faster or stronger. But poker and games other games like it are based on information. In the game every piece of information is important and the more information you have the better decisions you can make. Is it then that information is what separates professionals from amateurs? This paper attempts to analyze these questions by comparing how professional and amateur No Limit Texas Hold'em poker players use information and how the information influences their strategies

II. Literature Review

a. Poker and Game Theory

Since the inception of game theory economists and mathematicians have used simple forms of poker in order to study decisions and have tested subsequent findings against observed gaming. Borel, in his 1938 book *Applications aux Jeux des Hazard*, creates one of the first models of poker. This poker game, models two individuals with different abilities for betting. The simplified betting structure makes the game unrealistic, but admits solutions that reveal optimal strategies for each player.

In John von Neumann's and Oskar Morgenstern's *Theory of Games and Economic Behavior* (1944), numerous models of poker games are investigated including games with discrete and continuous hands and games with simultaneous bets and alternating bets. Von Neumann's poker games build off of Borel's model. The important difference between the two models is that Neumann's model includes a more complex and thus more realistic betting sequences. Neumann mathematically models these games and finds optimal solutions for play. One important theorem that von Neumann establishes within this work is his Minimax theorem. This theorem applies to two person zero-sum games, such as poker, and essentially says that in order for an individual to maximize his winnings he must employ an optimal mixed strategy based off of his opponent's strategy. If the poker players that this study analyzes play mixed strategies, it might be difficult to find consistent strategies to compare across professional and amateur players. Von Neumann's seminal work on game theory established the foundation for modeling poker and later economists and mathematicians use his work to expand models of poker.

Bellman and Blackwell (1949) build on and expand the poker models of von Neumann and Borel. The difference between their model and the two previous models deals with the restrictions on betting that von Neumann and Borel placed on their agents. Essentially this paper connects the different betting patterns used in the Borel and von Neumann models. In this model the bets are now able to be equal to zero or double the original bet proposed by the previous models. By allowing more betting scenarios than previous models, this model becomes more complex and more encompassing.

Nash and Shapley (1996) model a simple game of poker with three agents. The main addition that Nash and Shapley contribute is that they are the first researchers to model more than two individuals. The research contributes to ideas about mixed strategies.

Borel (1953) models zero sum games of chance in order to investigate successful strategies. The paper concludes that successful strategies must involve understanding your opponent and changing your strategy accordingly to capitalize on your opponent's strategy. Essentially the conclusion supports the Minimax theorem or the idea of mixed strategies.

b. Additional Models of Poker

Other models of poker are grounded in game theory, but expand on previously literature by focusing more on strategies such as bluffing. Friedman (1971) examines how past researchers in game theory have modeled bluffing and then builds a model to establish an optimal strategy for bluffing. The author uses a simplified version of poker and finds optimal strategies for bluffing based on perceived probabilities of winning.

Cutler (1975) examines strategies for both simple and complex forms of poker. The author analyzes a specific type of poker game called five card pot limit poker. In order to examine the complex/realistic version of this game Cutler makes a number of simplifying assumptions for a two person version of this game. With these assumptions Cutler is able to outline specific optimal moves that individuals should make with certain hands.

Ponssard and Sorin (1982) investigate optimal strategies for zero sum games with almost perfect information. One such game they model is a simplified poker game. The authors establish that two important factors affect an individual's strategy when playing poker; one the information revealed such as cards and betting patterns of opponent and two the potential payoffs of certain moves, essentially the pot size.

c. Poker Models and Computer Science

There is a significant gap between papers that model poker. Originally simple models of poker were investigated in the field of game theory. Attempts to solve more complex models were hindered until the advent of computers that were able to execute high level computations. The papers in this category use computers in order to study more complex and realistic models of poker.

Billings et al (2003) uses game theoretic models to investigate actual poker games with computer software. The authors use programs that are based on game theoretic models in order to create computer software that can play a type of poker game called Texas Hold'em. These authors are the first to successfully create software that outplays human players in full scale two person games.

Gilpin and Sandholm (2007) model a specific type of poker game called Texas Hold'em and investigate whether the strategies they find are equivalent to strategies outlined in game theory models. The authors base their computer code on game theorems, primarily the Minimax theorem, and attempt to create a program that outperforms other programs in an actual Texas Hold'em game. The authors advance the work Billings et al by using different programming techniques and thus establish a stronger program.

d. Prospect Theory

Kahneman and Tversky (1979) established the prospect theory as a critique for expected utility theory. Before Kahneman and Tversky expected utility theory was used to explain how people make decisions in situations that involve risk. The main critique of this theory is how people value percentages. Expected utility theory weighs outcomes based on their probabilities, but Kahneman and Tversky find that people do not choose outcomes based on probabilities. Essentially they find that individuals overweight outcomes that are certain even though these outcomes could lead to a lower expected payoff than alternative options. This analysis shows that individuals have difficulties discerning probabilities when making decisions and so it is important to the analysis of any game of chance that requires individuals to interpret probabilities and expected payoffs.

Kahnemand and Tversky (1992) expand on their previous literature regarding prospect theory. The authors discuss the research that occurred between this study and their original study of prospect theory. They also explain shortcomings of the original theory and explain how new additions have fixed these problems. The authors also present empirical evidence to support the prospect theory.

e. Measuring Skill

An important aspect of games that involve chance, such as poker, is how much skill is involved in the game and how do players of different skill levels play relative to each other. The next series of papers investigates skill in games of chance.

Larkey et al (1997) examines how skill factors into success in games. The authors explain that game theory typically assumes away differing levels of skill. The authors model a type of poker game and attempt to measure skill by creating player types based on specific strategies. The researchers run the model and find solutions for the successfulness of different types of players.

Borm and van der Genugten (2001) model several types of games with chance elements in order to establish relative skill levels for legislative purposes. The authors' model builds off of Larkey's model. The results show a spectrum of games across differing levels of skill and chance. The poker game Texas Hold'em is higher on the spectrum than most other chance games that are tested.

Dreef et al (2004) build off of Larkey et al, but instead model games with chance elements in an attempt to establish a concrete judicial system for measuring the legitimacy of games with chance. These authors also establish a simplified version of poker with player characteristics that represent different strategies. Dreef et al model these strategies and estimate individual expected payoffs for each player type.

Dreef et al (2006) investigate how information in chance games affects the strategies of individuals. The authors build a model that attempts to incorporate information. The authors find that information in games with chance elements is very important, but that this information can only be relevant to the randomness of the game, or the cards, and cannot fully predict the randomness of one's opponent.

Levitt et al (2010) investigates whether individuals play according to Minimax strategies in games. Levitt does this by creating a simple card game and having different groups of people play the game in order to see if these individuals' strategies are consistent with the Minimax theorem. Two groups that Levitt uses are students and professional poker players. Interesting results from this study show that both groups did not play the fabricated card game significantly close to the Minimax theorem. Also it seems that the strategies that the students used were similar to that of professional poker players. This result is interesting because one would imagine that because professional poker players are well versed in zero-sum games that their strategies would differ in some significant way from students or relative amateurs of zero-sum games.

The proposed model of this paper intends to expand on the current literature surrounding poker and zero sum games in general by empirically testing the strategic differences between amateur and professional No Limit Texas Hold'em players.

III. No Limit Texas Hold'em Background

The specific game that will be analyzed is a popular form of poker called No Limit Texas Hold'em. The game uses a standard deck of 52 cards in which there are values from 2-10 and face cards including jack, queen, king, and ace. The deck also has four suits including hearts, diamonds, spades, and clubs. Money in the game is called chips and in specific hands the chips that individuals are trying to win is called the pot.

No Limit Texas Hold'em has four stages and each stage has corresponding betting rounds. These four stages are called the preflop, flop, turn, and river. The first stage of the game is called the preflop and in this stage each individual is dealt two cards that are not viewed by the other players. In the next three stages five community cards are revealed. Community cards are cards that are seen by every player. The purpose of the game is to create the best five card hand with the seven cards that each individual sees, two private preflop cards and five community cards. The difference between the last three stages is the number of community cards that are revealed. The flop is the second stage and three cards are revealed. After the flop one card is revealed on the turn. Finally the river stage reveals the last community card.

In each stage of the game there is a corresponding round of betting where each player must make one of four strategic decisions. The player can either raise/bet, check, call, or fold. A bet is when an individual decides to place money in the pot. A raise is subtly different in that a player raises when he places additional money in the pot on top of a previous bet. Essentially the difference between a bet and a raise is whether or not there was a previous bet. This discrepancy is subtle and not important for this paper. When there are no previous raises an individual can check. This move is essentially passing. If there was a previous raise, other than re-raising, an individual has to make one of two decisions, call or fold. Calling means that the player is putting out the amount of the raise. Folding is when a player decides not to put out the amount of the raise and forfeits his hand. As noted earlier there are four rounds of betting, preflop, flop, turn, and river. In order to simplify the game this analysis only focuses on the preflop of a No Limit Texas Hold'em game.

Another important aspect of the game is position. Position is essentially when players act. The dealer position is the last position to be dealt. This position is represented by a white button that is passed around the table in a clockwise direction. The dealer button moves one position after each hand. Cards are also dealt in a clockwise direction. The two positions after the dealer position are called the small blind and the big blind. In the preflop stage of the game these two positions are forced to place money in the pot. In the specific game that this paper studies the big blind is \$800 and the small blind is \$400. After these two positions there is the third position which is typically referred to as "under the gun." This position acts first and can either call \$800, fold, or raise. This continues around the table until the betting arrives at the big blind, who is the last position to act in the preflop stage. Because the big blind is able to observe the moves of all the players before making a decision this position is advantages. Because of this, players in the third position are able to do something called a straddle. A straddle is when the third position puts in double the big blind, \$1600, before looking at his cards in order to gain the advantageous last position. A straddle can theoretically continue to move around the table.

For example, the third position could straddle to $1600 and this then allows the fourth position to straddle to $3200. As noted this could continue, but in the data set that this paper utilizes $3200 was the highest straddle reached. Aside from straddles, small blinds, and the big blinds, each player must also place an ante of $100 in the pot for each hand regardless of position.

IV. Methodology

a. Data

Data for this model was compiled from a television series called High Stakes Poker. The data was collected by manually recording specific variables of each hand. This series features cash games between professional poker players and amateur poker players. The designation of professionals and amateurs is based on what the individuals do for a living. Professionals play poker for a living and amateurs do not. In the data set there are thirteen professionals and seven amateurs.

Variable	**Name**
Pr(Call or Raise)	A player can make one of two decisions fold or call/raise
PROF	Dummy variable for professionals
HAND	Hand strength in percentage chance of winning the hand
CHIP	The number of chips each individual has
BETPOT	Current bet divided by current pot size
PEOPLE	Number of actors that move behind an individual
INVEST	Number of mandatory chips invested
IHAND	Interaction term for hand strength
ICHIP	Interaction term for number of chips

IBETPOT	Interaction term for bet to pot ratio
IPEOPLE	Interaction term for number of people
IINVEST	Interaction term for mandatory money invested

b. Data Issues

The data used for this analysis has some shortcomings. As noted earlier the data for this analysis was manually collected from recording pieces of information from season seven of the television show *High Stakes Poker*. One of the main problems with this source is that the show does not include all hands that were played during the actual game of poker. It is assumed that because the show's objective is to get viewers that the executives chose to show the most interesting hands. If this is true that would mean the hands that were selected to be presented were not selected randomly and thus this could create selection bias within the dataset. If this bias in the dataset is significant then the results that the dataset yields could be inconsistent with what is actually occurring.

This problem is minimized by the nature of the analysis used. For simplicity this analysis has been limited to the preflop stage of the game. That is it only represents one of the four rounds of the game. Most hands end in one of the last two rounds of the game and these rounds are usually where the most interesting plays occur. Thus if the producers of the show are selecting hands based on how interesting they are, this does not necessarily mean that the preflop hands that are shown are more interesting than the ones that are not being shown. And because the last two rounds are usually the most interesting, it could be very likely that most hands were chosen independently of what happened in the preflop stage. Furthermore, even if the selections were based only on the preflop stage of the game there is still no convincing evidence to say that individuals would drastically change their strategies in hands that are more interesting to viewers than in hands that are less interesting to viewers.

Another limitation of the data set is that the chip stacks for the individuals are not shown, but this could be an important variable. If an individual has a lot of chips relative to other players that individual can use his chips to essentially “bully” other players by making aggressive moves independent of other factors such as hand strength. Knowledge of the chip levels during every hand would be ideal, but those data are not available. If the analysis was to include the amount of chips there would be significantly less observations. The data set has 250 observations where chips are accounted for and 1,354 observations if we disregard chips.

Aside from the fact that the observations are much greater when disregarding chips, the role of chips in this specific game of poker are not severely important. As noted earlier the number of chips that an individual has are important for strategies in poker, but this importance is different in different structured games of poker. A tournament for example has a finite number of chips. In tournaments chips are very important because the structure of the game limits players from buying more chips. This creates a situation in which there are vast disparities between the chip stacks of individuals. The game that this analysis is examining is a cash game. In a cash game each individual can purchase more chips at any time unless they are in the middle of a hand. Essentially this means that individuals’ chip stacks are only limited to their bank account. Thus the role of chips in this game is diminished and by disregarding them from the main regression should not significantly affect the results.

c. Model Specification

In crafting the model some simplifications are made to the potential moves an individual can make. As noted in the No Limit Texas Hold'em background section a player has four actions to choose from when making a decision: fold, check, call, or raise. For simplicity reasons this study simplifies this decision to a binary decision of either folding or calling/raising. Essentially the choice is between putting money in the pot, call/raise, or not putting money in the pot, fold. Consolidating calling and raising into one move is valid when you account for the amount of money that was bet or called before each player's decision. In the model this is accounted for in the bet to pot ratio.

The model also disregards the action of checking. Checking is an interesting option that makes it difficult to consolidate with other moves in order to create a binary model. In order to retain the choice of either putting money in the pot or not putting money in the pot, checking would have been consolidated with the folding option. Intuitively this consolidation would not be very valid. This is because in the data set the check actions all come from the positions of big blinds or straddles. This means that these individuals did not have an option to call because their money was already mandatorily placed in the pot. Thus an instance could occur where an individual checks when given the option he would have called. If checking would have been included, the move would be marked as a fold in the model and could lead to inconsistent results. To fix this potential problem the observations that involved checking, 16 out of 1371 observations were eliminated from the data set. The elimination of the observations that included checking had no significant impact on the results.

Binary Probit without Chips:

$$\Pr(Call\ or\ Raise)_i = \propto + \beta_1 Prof_i + \beta_2 Hand_i + \beta_3 Bettpot_i + \beta_4 People_i + \beta_5 Invest_i + \beta_6 Ihand_i + \beta_7 Ibettopot + \beta_8 Ipeople_i + \beta_9 Iinvest_i + \epsilon_i$$

(1)

Binary Logit without Chips

$$\Pr(Call\ or\ Raise)_i = \propto + \beta_1 Prof_i + \beta_2 Hand_i + \beta_3 Bettpot_i + \beta_4 People_i + \beta_5 Invest_i + \beta_6 Ihand_i + \beta_7 Ibettopot_i + \beta_8 Ipeople_i + \beta_9 Iinvest_i + \epsilon$$

(2)

Binary Probit with Chips:

$$\Pr(Call\ or\ Raise)_i = \propto + \beta_1 Prof_i + \beta_2 Chip_i + \beta_3 Hand_i + \beta_4 Bettpot_i + \beta_5 People_i + \beta_6 Invest_i + \beta_7 Ihand_i + \beta_8 Ichip_i + \beta_9 Ibettopot_i + \beta_{10} Ipeople_i + \beta_{11} Iinvest_i + \epsilon$$

(3)

Models one through three represent the three models that will be run to investigate the differences in strategies among professional and amateur poker players. The first model is the main regression that this study will focus on. The model is a binary probit in which the dependent variable is the probability of calling or raising. A probit model is chosen for the main model because logit models are generally used for data that has a disproportionate amount of ones or zeros. The data used has about the same amount of folds and calls or raises, thus probit is a better choice for the main model. For reference purposes model two shows the results for a logit regression. As noted in the data issues section, the number of chips is only available for a small portion of the observations. Model three uses these observations and includes chips as an independent variable.

An empirical analysis that examines differences in the strategies of professional and amateur poker players has never been done. Models of poker have attempted to capture skill in different games of chance and different types of players Larkey et al (1997), Borm and van der Genugten (2001), Dreef et al (2004). One conclusion from these authors suggests that skill in poker has a significant effect on the game's outcome. Since poker is a game of information then it must be that the skilled players are better using the information to make decisions. In this analysis it is assumed that professionals are more skilled than amateur players. Thus professionals should be more encompassing when making decisions based on the information they are given. That is the information that is revealed within the game should affect the decisions of professionals more than amateurs.

Hand strength represents an individual's percentage chance of winning the hand from the preflop position with eight players in the hand. The percentages were taken from pokernews.com which gives the probabilities of winning a hand based on the number of individuals in the hand and the value of an individual's cards. Higher percentages correspond to better hands. Better hands mean a higher percentage chance of winning. So it can be assumed that if an individual has a higher chance of winning the hand that individual will be more likely to call or raise and less likely to fold. Thus the coefficient on this variable should be positive.

The prospect theory explains that individuals have difficulties discerning probabilities when making decisions Kahneman and Tversky (1979) and Kahnemand and Tversky (1992). The variable of hand strength represents the percentage chance of winning the pot with a specific preflop hand. Based on the prospect theory it would make sense that the individuals within the game could have trouble in discerning between their probabilities of winning with different cards. For example individuals would most likely be able to distinguish between the chance of winning with AA, the best starting hand, and 7 2 off suit, the worst starting hand. Individuals might have a more difficult time distinguishing between the probabilities of winning with hands such as 10 9 suited and 10 9 off suit. Because we have assumed that professionals are able to better interpret information when making decisions, we can predict that these professionals will be better at distinguishing between the probabilities of winning with a certain hand than amateurs. Thus the coefficient for the interaction term of hand strength should be positive.

The bet to pot ratio shows what a player must call relative to the pot size. Thus if this number is large, a player is getting relatively bad odds because the money he will have to call is closer to his potential winnings or the pot. On the other hand if this number is small the pot is large relative to what a player must call. This then gives the player better odds and makes him more inclined to call. Thus the coefficient for this variable should be negative. If the professional players are more encompassing in their decisions, like we have hypothesized, then the interaction term for this coefficient should also be negative.

Information is crucial for making decisions in games such as poker. The more information an individual has the better the decisions they can make. Past researches who have modeled poker, and other games like it, have expressed the importance of information and have tried to capture its effect in their models. Ponssard and Sorin (1982) concluded that information is crucial for crafting strategies and making decisions in zero sum games such as poker. The number of people in the hand is a crucial variable that helps to measure information. This number represents the amount of people that are acting behind a player. If for example an individual is in the fifth position and there are eight players then this individual has three players behind him. When an individual is in a late position, such as eighth to act, then this individual has an advantage. He is able to view the actions of every player before he acts. When other players make a decision they reveal information that could be used to affect the decisions of individuals that act after them. Individuals in early positions are at a disadvantage because there is more uncertainty about what the players after them will do. The more uncertainty there is, the riskier it is to make an aggressive play such as calling or raising. Thus the coefficient on this variable should be negative. That is the more actors that are behind an individual the less likely that individual will call or raise. Furthermore because we are assuming that professionals are more encompassing in their decisions, the interaction term for this variable should also be negative. This would mean that professionals are further valuing this piece of information in their decision making process.

The investment variable represents the amount of mandatory chips each player has invested in the pot before seeing their hand. This includes antes, small blind, big blind, and potential straddles. From an economic perspective this value should be seen as a sunk cost because the payments are mandatory and thus independent of any strategy. If the variable is perceived as a sunk cost then it should have no bearing on any decisions and the variable should be insignificant.

The nature of the variable for the number of chips an individual has been discussed in the data issues sections. Essentially more chips can give an individual more leeway to make aggressive plays such as calling or raising. Thus the coefficient for this variable should be positive. As with previous interaction terms, the interaction term for this variable should be positive denoting that professionals are using this information to a greater extent.

d. Model Limitations

One major critique that could be made of the current model is that it disregards the fact that current actions of individual players could potentially be affected by the past occurrences within the game. This could be a fundamental problem for numerous reasons. Strategies in general are crafted based on the strategies of other individuals in the game. For example if individuals have been playing passively, an individual might be more inclined to play aggressively simply because he knows that individuals have been playing passively. Another instance where past occurrences could affect play occurs when an individual "gets on tilt." Tilt describes when individuals make emotional or irrational moves because past actions of the game have affected their emotions and thus their strategy.

The current model does not include a variable that measures past instances. The reason for not including a measure of past instances is that it is nearly impossible to account for historical occurrences in this specific game. Money lost or gained could be a potential measure of this affect, but as discussed in the data issues section, this information is not available. Even if this variable was available, it would be an inadequate representation of historical occurrences. One reason that this would be inadequate would be because the players who partake in this game have played with each other on numerous other occasions. Also because these individuals are televised, it would make sense that at least the professionals have studied the strategies of the other players outside of actually playing with them. As noted earlier strategies are formed based on the strategies of opponents and it would be a daunting task to somehow measure all the interactions that each player has had with the other players in order to try to create a variable that measures these historical interactions. Gains and losses are also inadequate for measuring the tilt of a player. Tilt deals with a player's emotions and how these are affecting their strategy. These emotions could be external to the game and thus would be very difficult to measure with any variable. A variable that would somehow measure historical occurrences and test how these are affecting current situations would be used in an ideal situation. But limitations on the data set and the innate complexity of the game itself limit this analysis.

V. Results and Analysis

Table 1: Regression Output: Models 1-3

Independent Variable	**Model 1** Probit Model	**Model 2** Logit Model	**Model 3** Probit with Chips
PROF	0.532* (0.132)	0.473* (0.156)	0.211 (0.617)
HAND	12.227* (1.087)	13.044* (1.305)	13.940* (3.208)
CHIP	--	--	-0.000 (0.000)
BETPOT	-0.488* (0.165)	-0.821* (0.250)	-0.031 (0.607)
PEOPLE	-0.018 (0.023)	-0.028 (0.025)	-0.080 (0.057)
INVEST	-0.0001 (0.0001)	-0.0001 (0.0001)	-0.0002 (0.0002)
IHAND	0.557 (1.314)	0.759 (1.561)	-0.756 (3.683)
ICHIP	--	--	0.000 (0.000)
IBETPOT	-0.716* (0.225)	-0.637** (0.316)	-0.621 0.685
IPEOPLE	-0.109* (0.0298)	-0.1093* (0.0326)	-0.050 (0.072)
IINVEST	-0.0002** (-0.0002)	-0.0002*** (0.0001)	0.0002 (0.0003)
Pseudo R^2	0.47	0.47	0.50

*Significant at 0.01, **Significant at 0.05, ***significant at 0.1

Table 1 shows the results from the regressions. Logit and probit regressions return coefficients that are hard to interpret and because of this the model uses marginal effects to find the true value of the coefficients. Thus the coefficients can be interpreted like OLS coefficients. For example the interaction term for hand denotes that a one percentage point increase in the chance of winning with a hand will make professionals 0.557% more likely to call than amateurs would be with the same one percentage point increase in the chance of winning the hand.

The results for the main model are mostly consistent with the predictions laid out in the data and methodology section. Model three represents the results from the limited data set that includes the amount of chips each player has. Some of the results are inconsistent with the predictions laid out in the methodology section. The inconsistency in results is probably related to the small sample size and thus these results should not be considered conclusive.

The main model for this analysis is model one. This model closely matches the predictions that were made in the methodology section. For each variable the signs are consistent with the predictions that were made. The crux of this analysis comes from the interaction terms. The signs of the coefficients of the interaction terms are consistent with the signs of the four variables that they correspond to. This shows that professionals value each variable, or each piece of information, more than the amateurs. Essentially professionals use the information that they are given more effectively than amateurs. This could explain why professionals generally perform better than amateurs. Texas Hold'em is a game where people make decisions based on very limited information. The more information that individual has the better the decision he is able to make. Thus because professionals put more weight on the information that they are given it makes sense that they would make better decisions and in the long run outperform amateur players.

A curious result is that the interaction term for investment is significant for professionals. As noted earlier the investment variable represents mandatory payments to the pot that are independent of any strategy and thus should be thought of as sunk costs. It is interesting then that professionals value this piece of information as significant. A potential problem that could have occurred with the investment variable is that it could be correlated with the people variable. As noted in the No Limit Texas Hold'em background section the positions that pay these mandatory payments are the last positions to act in the first round of the game. For example if there are eight people then the big blind will be the eighth person to act. Because of this the positions that have high mandatory investments will also, on average, have a lower number of people that will act behind them. This then could be a potential multicollinearity problem. A VIF test was used to test for multicollinearity and the output is available in appendix AI. An average VIF of 1.28 shows that multicollinearity is most likely not having an effect on the results.

VI. Conclusion

Being that this is the first empirical model to compare strategies of amateur and professional poker players, there is a lot of potential research that could build on this analysis. Future researchers could expand on the sample size by potentially including other seasons of *High Stakes Poker* and testing to see if the results are consistent. They could also attempt to create the same analysis, but fix some of the potential problems that were outlined in this analysis such as finding data that included all hands, chips, and some type of measure of past instances. It is important to note that although the amateurs in this analysis are not professional poker players by trade, they are still considered to be very skilled poker players. It would be interesting to see an analysis that compares professional poker players with amateurs of an even lesser skill level. Also the fact that professionals are not viewing the mandatory investments as a sunk cost is an interesting result. An interesting analysis could focus on this and attempt to find a reason for this significance.

The analysis has attempted to answer questions concerning how poker players make decisions and how these decisions differ for different levels of poker players. The analysis has shown that information that is revealed within the game is what players are using in order to form strategies and make decisions. Furthermore this analysis has shown that professionals are more encompassing with their decisions. That is when professionals are making decisions they are able to better use the information within the game relative to amateurs.

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APPENDIX

AI. Multicollinearity Test

Variable	VIF	SORT VIF	Tolerance
HAND	1.00	1.00	0.995
BETPOT	1.01	1.01	0.988
INVEST	1.55	1.24	0.647
PEOPLE	1.55	1.24	0.647
Mean VIF	1.28		