

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

FACULTY OF ECONOMICS AND MANAGEMENT
DEPARTMENT OF INFORMATION TECHNOLOGY



Bachelor thesis

Analysis of on-line poker gaming

Author: Kryštof Hereš

Supervisor: Ing. Miloš Ulman, Ph.D.

© 2014 CULS

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Department of Information Technologies

Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

Hereš Kryštof

Economics and Management

Thesis title

Analysis of on-line poker gaming

Objectives of thesis

The main objective of this thesis is to analyze on-line poker games. The partial goals of the thesis are:

- 1) to characterize current on-line poker situation in the world,
- 2) to characterize poker software and its providers,
- 3) to make a comparative analysis of various gaming strategies.

Methodology

Methodology of the thesis is based on study of information resources and analysis of statistical data. The practical part will be based on a comparative analysis of software products. The study will also include authors own experience. Based on the theoretical knowledge and results of analysis will be formulated final conclusions.

Schedule for processing

- 1) Preparation and study of specialized information resources, refinement of partial goals and selection of work process: 04-06/2013
- 2) Processing of literature overview according to information resources: 07 - 10/2013
- 3) Development of the own solution, discussion and evaluation of results: 11/2013 - 01/2014
- 4) Creation of the final document of the thesis: 02 - 03/2014
- 5) Submission of thesis and abstract: 03/2014

The proposed extent of the thesis

30 - 40 pages

Keywords

On-line poker, poker, internet gambling, e-business, Pokerstars.com , cyber psychology, texas holdem.

Recommended information sources

BRUNSON, Doyle. Online poker: your guide to playing online poker safely. 1st ed. New York: Cardoza Pub., c2005, 192 p. ISBN 15-804-2132-6.

CSCW 2004: computer supported cooperative work : conference proceedings, November 6-10, 2004, Chicago. New York, N.Y.: ACM Press, c2004, xiv, 630 p. ISBN 15-811-3810-5. Available at WWW: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.72.3956&rep=rep1&type=pdf>

NAVARRO , Joe. Phil Hellmuth presents Read'em and reap: a career FBI agent's guide to decoding poker tells. [Nachdr.]. New York: Collins, 2008. ISBN 978-006-1198-595.

BRUNSON, [Doyle a With Mike COCHRAN]. The godfather of poker: Doyle Brunson, an autobiography. 1st ed. Las Vegas, NV: Cardoza Pub, 2009. ISBN 978-158-0422-574

HANSEN, Gus a With Mike COCHRAN]. Every hand revealed: Doyle Brunson, an autobiography. 1st ed. New York, NY: Lyle Stuart, 2008. ISBN 978-081-8407-277.

The Bachelor Thesis Supervisor

Ulman Miloš, Ing., Ph.D.

Last date for the submission

March 2014


doc. Ing. Zdeněk Havlíček, CSc.

Head of the Department




prof. Ing. Jan Hron, DrSc., dr. h. c.

Dean

Prague November 6, 2013

Declaration

I declare that I have worked on my bachelor thesis titled "Analysis of on-line poker gaming" by myself and I have used only the sources mentioned at the end of the thesis.

In Prague, 13th March 2014

Kryštof Hereš

Acknowledgements

I would like to express great appreciation to my supervisor Ing. Miloš Ulman Ph.D. for his valuable and constructive suggestions during the planning and development of my thesis. I would also like to extend thanks to my family and my girlfriend. They have been kind enough to provide me an excellent moral support and encouragement.

Analysis of on-line poker gaming

Analýza on-line hraní pokeru

Summary

This thesis analyses the card game poker, specifically its on-line version. The aim of this work is to show poker as a game which does not depend only on luck and coincidence, but also on the abilities of players. The introduction of my thesis describes why poker is such an attractive game and the part also contains reasons that led me to choose on-line poker as a topic for my bachelor thesis. The theoretical part focuses on the history of poker, its rules and describes the basic mathematical and statistical aspects of the game. The practical part shows the use of poker mathematics in practice and describes at great length the calculation of variance on two specific poker tournaments. The final discussion describes the results of my practical analyses and discusses fulfilment of stated hypothesis.

Keywords: On-line poker, poker, internet gambling, on-line gaming, pokerstars.com, probability, statistics, Texas hold'em.

Souhrn

Tato bakalářská práce se zabývá analýzou karetní hry poker, konkrétně její on-line verzí. Cílem této teze je ukázat poker jako dovednostní hru, při které nezáleží pouze na štěstí a náhodě, nýbrž také na umění jednotlivých hráčů. V úvodu mé práce je popsáno, proč je poker tak atraktivní hrou a také důvody, které mě vedly k výběru tohoto tématu. Teoretická část je zaměřena na historii pokeru, jeho pravidla a popisuje základní matematické a statistické jevy této hry. Praktická část ukazuje využití pokerové matematiky v praxi, dále se také zabývá podrobným výpočtem variace dvou konkrétních pokerových turnajů. Závěrečná diskuze popisuje výsledky mé praktické analýzy a rozebírá naplnění dané hypotézy.

Klíčová slova: On-line poker, poker, internetový hazard, on-line hraní, pokerstars.com, pravděpodobnost, statistika, Texas hold'em.

Table of contents

1	INTRODUCTION	10
2	THESIS OBJECTIVE AND METHODOLOGY	12
2.1	THESIS OBJECTIVE	12
2.2	METHODOLOGY	12
3	LITERATURE REVIEW	13
3.1	HISTORY OF POKER	13
3.1.1	ON-LINE POKER	14
3.1.2	POKER BOOM IN 2003	14
3.2	RULES OF POKER	15
3.2.1	NO LIMIT TEXAS HOLD'EM	15
3.2.2	WINNING COMBINATIONS VALUES	17
3.2.3	FORMATS OF PLAY	20
3.2.4	POSITION AT THE TABLE	21
3.2.5	HOW ON-LINE POKER ROOMS PROFIT	23
3.3	LEGAL ISSUES OF ON-LINE POKER	23
3.3.1	TAXES	23
3.3.2	BLACK FRIDAY	24
3.4	MATHEMATICAL ASPECTS OF POKER	25
3.4.1	POT ODDS	25
3.4.2	HAND OUTS	26
3.4.3	HAND ODDS	26
3.4.4	EXPECTED VALUE	26
3.4.5	VARIANCE	27
3.4.6	STANDARD DEVIATION	28
3.4.7	NORMAL DISTRIBUTION	28
3.5	POKER TOOLS	29
3.5.1	ODDS CALCULATORS	29
3.5.2	HAND CONVERTERS	29
3.5.3	HUD PROGRAMS	29
3.6	POKER STATISTICS	30
3.6.1	PRE-FLOP STATISTICS	31
3.6.2	POST-FLOP STATISTICS	33
3.7	PLAYING STYLES	35
3.7.1	TIGHT PASSIVE (THE ROCK)	36
3.7.2	LOOSE PASSIVE (THE CALLING STATION)	37
3.7.3	TIGHT AGGRESSIVE (TAG)	38
3.7.4	LOOSE AGGRESSIVE (LAG)	39
3.7.5	MANIAC	40

4	ANALYTICAL PART	42
4.1	DECISION-MAKING PROCESS IN POKER	42
4.1.1	STEP 1 - POT ODDS	42
4.1.2	STEP 2 - OUTS	43
4.1.3	STEP 3 - HAND ODDS	43
4.1.4	STEP 4 - COMPARE POT ODDS AND HAND ODDS	43
4.1.5	STEP 5 - EXPECTED VALUE	44
4.2	USE OF VARIANCE IN POKER	44
4.2.1	TOURNAMENT 1	45
4.2.2	TOURNAMENT 2	45
4.2.3	CALCULATION	45
5	EVALUATION OF RESULTS	51
5.1	DECISION-MAKING PROCESS IN POKER - RESULTS	51
5.2	USE OF VARIANCE IN POKER - RESULTS	51
6	CONCLUSION	53
7	REFERENCES	54
7.1	BIBLIOGRAPHY	54
7.2	ON-LINE SOURCES	54

1 Introduction

Poker is an exciting card game that offers a great variety of actions underlined by simple rules. The card game has become international phenomenon over the last few years and it is played by millions¹ of people from many different countries. For someone, poker means innocent playing cards with friends. For others, it is a source of livelihood. Poker is currently the most popular card game in the world. The game combines elements of psychology and mathematics. To succeed, you need to analyse your game and properly respond to the playing style of your opponents. It is an ideal game for competitive people because of endless possibilities of improvement. Poker is mostly played by men but it is also getting popular among women and there are many females playing on the professional level. The only restrictions for playing poker are the local legal requirements. In the Czech Republic the only restriction for playing poker is the minimal age of 18.

Unfortunately, poker is very often seen by the society as a pure gambling and it is wrongly classified in the same category as roulette, blackjack or slot machines. For this reason I decided to choose "Analysis of on-line poker gaming" as my bachelor thesis topic and support the fact that poker games can be influenced by players in many ways. I have been playing on-line poker for the last 5 years and the more I studied the game, the more I understand that it is not just a game of coincidence. It is true that the fate of a player is not entirely under his or her control and any player has a chance to win particular game or tournament. But that does not mean that everyone has the same likelihood of success in a long-term. Many variables are involved in every decision and that makes poker a skill game. Unlike roulette and other games, the players do not compete against casino itself, but against each other. Great poker players distinguish from the bad ones by good knowledge of mathematics, the ability to adapt their tactics to specific scenarios, thinking ahead, by discipline and the desire to constantly learn.

Most of the poker players play on-line because of the comfort of playing from their homes and the ability to play several tournaments at one time. Plus, there are many other advantages such as playing anonymously under nickname (which is favourable if you are a

¹ THEPPA.ORG. U.S. Online Poker Survey 2012. In: [online]. United States: Poker Players Alliance, 2012 [cit. 2014-03-09]. Available at: <http://www.scribd.com/doc/106952469/U-S-Online-Poker-Survey-2012>

winning player and you don't want to be recognized), large selection from many games and different limits and finally, the speed of the game which is incomparably quicker than playing live. On the other hand, in live poker you can see your opponent's physical tells and signals that can't be utilized on-line, which is unpleasant because poker is a game based on incomplete information. The game is developing with their players and nowadays there are hundreds of educational sites, videos and books that help them in improving their game.

2 Thesis objective and methodology

2.1 Thesis objective

The main objective of this thesis is to analyse on-line poker games and to prove the hypothesis that poker games are not completely about luck and the results can be influenced by players. The partial goals of the thesis are to characterize current on-line poker situation in the world, to characterize poker software and its providers, to present different gaming strategies, to demonstrate the use of mathematics in poker and to make a comparative analysis of various game options.

2.2 Methodology

The methodology of the thesis is based on study of information resources and analysis of statistical data. The first chapter of the practical part is based on the practical use of poker odds and probabilities. The second chapter is focused on a comparative analysis of two different tournaments and their statistical variance. The analytical part also include analysis of real poker game recorded by the author. The final conclusion is formulated based on theoretical knowledge and results of analysis.

3 Literature review

3.1 History of Poker

The exact origin of poker is not known. It is believed that the birth of poker is dated to the first decade of the 19th century. It firstly appeared in former French territory in New Orleans, Louisiana and was played with a deck of 20 cards. The name was probably derived from the German card game Pochen or French game called Poque². And it is considered that direct predecessor of poker is a card game named Primero, which enjoyed a great popularity throughout the Europe in the 16th century.

The first dated reference about poker is from James Hildreth's book "Dragoon Campaigns to the Rocky Mountains", published in 1836. But later publications from Jonathan H. Green and Joe Cowell show that poker has been played already in 1829. These two authors independently described poker as a game played with a 20-card pack which is dealt amongst four players who bet on their card combinations. Green's book "An Exposure of the Arts and Miseries of Gambling" describe how poker spread to the rest of the country on Mississippi riverboats, on which, gambling was a common form of entertainment. Extension of poker to other countries, particularly to Asia is credited to U.S. Soldiers.

In the middle 1830s the game altered to be played with 52 cards which made it more attractive because of more possible card combinations and more people being able to play at one table. Also, bigger card deck lead to more betting intervals, it enabled poor hands to be significantly improved and the role of luck and coincidence in the game decreased.

From the middle of the 19th century poker evolved into many new variants such as Stud poker (Seven-card stud), Lowball poker, Draw poker (Five-card draw) and Community card poker (Omaha, Texas Hold'em) which is without a doubt the most popular variant today². Modern poker tournaments are played in casinos and became

² PARLETT, David. A History of Poker. In: *Card Games: History of Poker* [online]. [cit. 2014-03-09]. Available at: <http://www.pagat.com/poker/history.html#birth-growth>

popular after the start of the first World Series of Poker (WSOP) in 1970 in Las Vegas, Nevada. In this time, first poker publications discussing the importance of skill and strategy in poker were published.

3.1.1 On-line poker

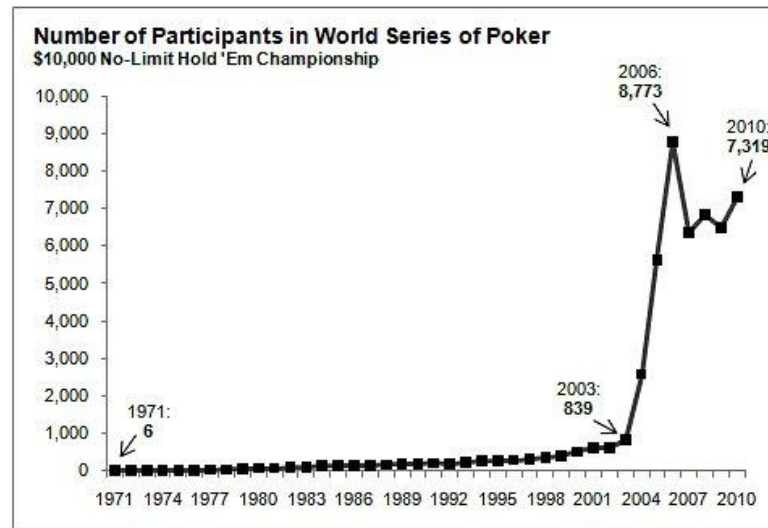
On-line poker started in the late 1990's as a terminal poker machine where players competed against virtual opponent. The first on-line real money poker room was launched in 1998 by Planet Poker Company and players were able to compete against real people for real money for the first time. Later, large companies with cooperative structures entered the market. Many different networks and poker rooms dominated the market for a certain period of time. Planet Poker era lasted from 1998 to 1999. Paradise Poker dominated from 1999 to 2003 and the years between 2003 and 2006 were era of Partypoker. Nowadays, there are many other big networks such as 888poker or I poker but none of them is as dominating as Pokerstars.com. Pokerstars is the biggest on-line poker company operating with more than 50% of the worlds on-line poker traffic (more than 50% of all on-line players use Pokerstars client software)³.

3.1.2 Poker boom in 2003

One of the first triggers of the boom was the release of the movie called "Rounders", in 1998. The film showed poker to general public as a game based on mathematics and psychology. Plus, in the same year, first on-line poker cardroom was introduced. These two events led to the occasional broadcasting of the World Series of Poker in television. But the main cause of the boom came in the spring of 2003, when amateur player Chris Moneymaker beat 839 opponents (including professional players) and won the main WSOP event. Moneymaker won his seat on Pokerstars on-line room and turned his 39\$ buy-in into 2.5\$ million. This fact launched a huge wave of interest in poker and Moneymaker became celebrity overnight. By the next year, the WSOP main event registered significantly larger field and by 2006, the tournament had more than 1000% increase in the number of players. The boom primarily influenced the no limit Texas hold'em poker variant because of its simple rules and wide space for action. Today, the

³ SMITH, Erik. Poker History: Online Poker Eras. [online]. 2011 [cit. 2014-03-11]. Available at: <http://www.pokerhistory.eu/history/historic-poker-eras>

popularity is still higher than in the pre-boom period but it is no longer significantly increasing. The number of WSOP main event tournament attendants remain stabilized near the 2010 level⁴.



Graph 1: Number of entrants in WSOP main event

Source: nytimes.com

3.2 Rules of poker

The game of poker has many variations but most of them share similar rules. The differences are usually in the number of betting rounds, hand values and in the number of cards each player is dealt. This part describes the rules of the most popular form of poker, no limit Texas hold'em.

3.2.1 No limit Texas hold'em

Texas hold'em poker is played with a deck of 52 cards containing 13 cards of different values in 4 different colours (spades, hearts, diamonds and clubs). The game is controlled by dealer and players play against each other. The game is usually played by 2 to 10 participants at one table. Before the game starts, dealer randomly draws which player will receive the button. This player has very advantageous position because it plays as a last person in every betting round. Therefore, this player can see opponent's actions before its own turn. After each hand, button is moved in a clockwise direction to another player.

⁴ CAESARS INTERACTIVE ENTERTAINMENT, INC. World Series of Poker. [online]. [cit. 2014-03-12]. Available at: <http://www.wsop.com/>

Before the dealer deals the cards, players sitting to the left side of the button and the player two to the left of the button are required to put mandatory bets on the table. The mandatory bets are called small blind (left to button) and big blind (two to the left of button). Blind bets are used in order of certainty of money in the pot. Also, these mandatory bets have a great significance in tournament poker because they help to eliminate and put pressure on players. In some Texas hold'em rules players can meet with mandatory bet ante. Ante bet is an obligatory bet for everyone sitting at the table and it usually represents one eighth of a big blind.

At the beginning of the game the dealer deals out two cards to every player (hole cards), starting with the one sitting on the small blind. The first betting round starts right after. Player sitting to the left of the player who posted big blind is first to act. This player can either lay down the cards (fold), even up the amount of the big blind (call) or increase the big blind bet by certain amount of its own choice (raise). The amount of raise has to be minimally twice the value of a big blind. All the following players can also express their action by one of the above stated moves. Plus, if the bet was already raised by some of the previous players, they can decide to increase the bet again (re-raise or 3bet). The first betting round is in poker terminology often called as a pre-flop phase, because it takes place before the first three community cards (flop) are dealt on the table. The following betting rounds are then called post-flop.

If all the players made a decision, dealer lays out three flop cards on the table. The second betting round follows. The first expresses the player who is one to the left of the dealer button. Players decide to check, fold or bet. If someone bets before them, players can increase the bet again. After the second betting round is completed, the dealer lays out the fourth community card on the table (turn). The third betting round has the same rules as second. When the third round is finished, the fifth and last community card is revealed by the dealer and fourth betting round is under way. Again, the fourth betting round follows the same principles as two previous. If two or more players remained in the game, they reveal their cards (showdown). The winner is determined by the value of his poker hand. The winner gets the money or chips in the pot. Often, it may happen that players have the

same rated hand and the pot needs to be equally split.

The pot can be also obtained any time during the game when one of the players forces others to fold and give up. Also, anytime the player can move all-in and play for all of his money or chips⁵.

3.2.2 Winning combinations values

Texas hold'em distinguishes ten winning combinations. The order is written according to the probability of their creation. The hands are sorted in descending order from the best to the worst combination. The combination is created by player's hole cards and community cards on the table. The player can but doesn't necessarily have to use his two hole cards in order to make a combination.

- **Royal flush**

*"Described: Five cards of consecutive ranks from ace down to ten, all the same suit. (Royal flush is merely the best straight flush.)"*⁵

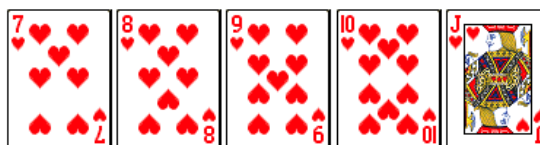


Picture 1: Royal flush

Source: Holdem-poker.wz.cz

- **Straight flush**

*"Described: Five cards of consecutive ranks, all the same suit. (Ace can be used low to form a five-high straight flush.)"*⁵



Picture 2: Straight flush

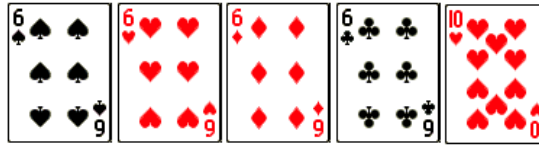
Source: Holdem-poker.wz.cz

⁵ BRUNSON, Doyle. *Online poker: your guide to playing online poker safely*. 1st ed. New York: Cardoza Pub., c2005. ISBN 15-804-2132-6

- **Four of a kind (poker)**

"Described: Four cards of a matching rank, plus an extra card.

*Ties: Highest ranking four of a kind wins."*⁵



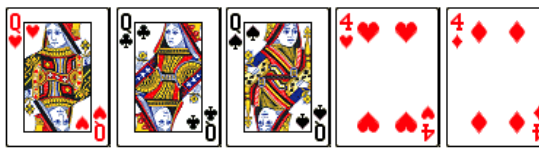
Picture 3: Four of a kind

Source: Holdem-poker.wz.cz

- **Full house**

"Described: Three cards of matching rank, plus two cards of a different matching ranks.

*Ties: Higher rank of the three of a kind within the full house wins."*⁵



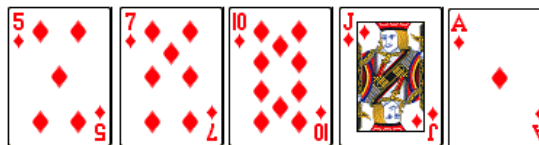
Picture 4: Full house

Source: Holdem-poker.wz.cz

- **Flush**

"Described: Five cards of the same suit that do not qualify as a straight flush or royal flush.

*Ties: Highest ranking card wins. If those are the same, next highest card wins, and so forth."*⁵



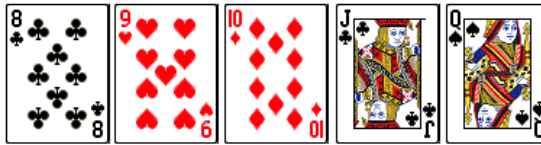
Picture 5: Flush

Source: Holdem-poker.wz.cz

- **Straight**

"Described: Five ranks in sequence. (Ace can be used low to form a five-high straight.)

*Ties: Higher rank beginning the sequence wins."*⁵



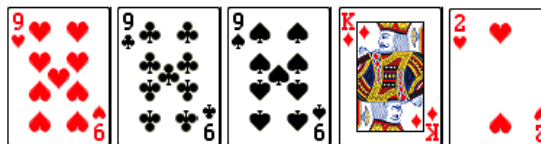
Picture 6: Straight

Source: Holdem-poker.wz.cz

- **Three of a kind**

"Described: Three cards of a matching rank and two extra cards whose ranks do not match.

*Ties: Higher rank of the three of a kind wins."*⁵



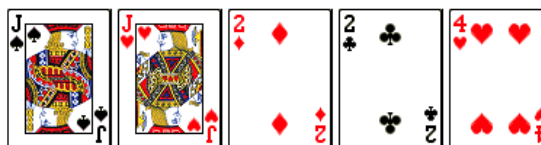
Picture 7: Three of a kind

Source: Holdem-poker.wz.cz

- **Two pair**

"Described: Two cards of a matching rank, plus two cards of another matching rank, plus one extra card.

*Ties: Highest pair wins. If tied, higher second pair wins. If still tied, higher extra card wins."*⁵



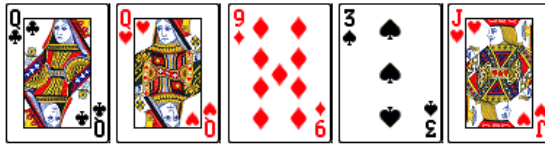
Picture 8: Two pairs

Source: Holdem-poker.wz.cz

- **One pair**

"Described: Two cards of a matching rank, plus three extra cards of all different ranks.

*Ties: Higher pair wins. If ranks are the same, highest ranking extra card not matched by opponent wins."*⁵



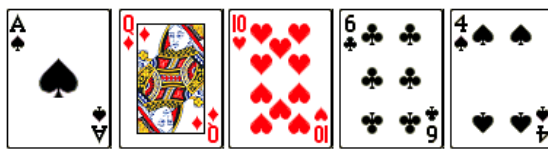
Picture 9: One pair

Source: Holdem-poker.wz.cz

- **High card**

"Described: Any hand that does not qualify for one of the categories listed above.

*Ties: Highest card wins. If the hands tie for high card, the second highest cards are compared, and so forth."*⁵



Picture 10: High card

Source: Holdem-poker.wz.cz

3.2.3 Formats of play

3.2.3.1 Cash game (ring game)

In cash game, players can enter and leave the game whenever they want. The chips the players buy-in directly represent real money. For example if a player makes a buy-in for 50\$, it receives chips in 50\$ value. Most of the games are limited by minimal and maximal buy-in.

3.2.3.2 Sit & Go (SnG) tournament

In sit and go tournaments, players are obliged to pay a certain entry fee in order to participate. The number of players is limited (for example: 6, 9, 27 seats). SnG ends at the moment when one player possess all the tournament chips and every other player is eliminated. Number of paid places and entry fee value is given in advance by the tournament rules. The buy-in fee does not directly represent real money. Players receive fixed amount of chips (for example player pays 5\$ entry fee and receives 1500 chips) and they are ranked accordingly to their elimination.

3.2.3.3 Tournament

This format does not differ very much from Sit & Go rules. The main difference is

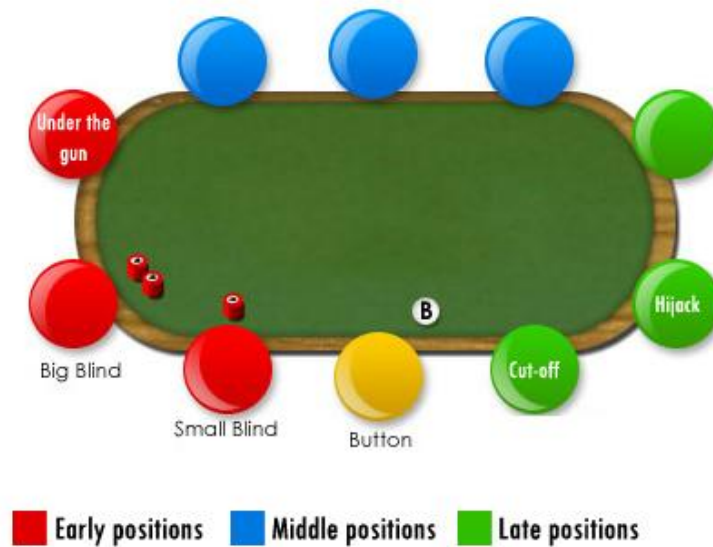
that the number of players is not limited. It means that the tournaments are played on multiple tables, more paid places (but also harder to reach) and it takes usually several hours to finish. Some of the tournaments are marked by the providers as guaranteed tournaments. This means that the minimal prize pool amount is guaranteed by the card room even if there is not enough players registered and the prize is not collected in their buy-ins. In other words, the provider makes a commitment to pay up the rest of the money into the prize bank.⁶

3.2.4 Position at the table

Position at the table is a very important factor which is very often underestimated by many beginners. The position of a player is determined by the position of the dealer button. The ability to play properly on different table positions can be the difference between winning and losing sessions. Bad players make mistakes in playing good looking combinations in bad positions and on the contrary, great players know how to play poor cards in strong positions.

Players who are first to act are in so called "early position", players who act after them are in the "middle position", and players who are last to act are in the "late position". The biggest advantage is held by the players in late positions. They obtain extra information about their opponents in earlier positions because they see how they reacted. Also, the more opponents fold, the bigger is the probability of your hand combination to be the best. The most favourable position is the button which gives the player a benefit in always responding as a last player with the exception of the first betting round. On the other hand, the blinds are the least advantageous positions because players have to contribute to the pot and they are always first to act in post flop action. For better idea of poker positions, see picture below where a ten seated poker table was used as a demonstration.

⁶ BRUNSON, Doyle. *Online poker: your guide to playing online poker safely*. 1st ed. New York: Cardoza Pub., c2005. ISBN 15-804-2132-6



Picture 11: Poker positions

Source: thepokerbank.com; edited by author

3.2.4.1 Early position

In early positions, it is recommended to be selective about the card combinations you play. It is the worst possible position at the table. Players raising from early position are assumed to have a good hand. But some clever players use this fact and raise the bet even with poor combination trying to scare opponents by representing strong cards. The seat which is first to act in the first pre-flop betting round is called "Under the gun" which refers to the fact of being sat on the most unsuitable position and also being under a gunfire of opponents.

3.2.4.2 Middle position

In middle positions, players can afford to play little bit more loose (more combinations) but still have to be cautious because there are few players to follow. It is not as advantageous as late positions but players at least have an idea how players sitting on late positions reacted.

3.2.4.3 Late position

Player sitting in late position has the benefit of being one of the last to act. The information that is gained by players sitting in late position allows them to play weaker combinations or fold strong cards depending on the action ahead of them. The seat one to

the right from button is in poker terminology called "cut-off" and the seat two to the right from button is "hijack".

3.2.5 How on-line poker rooms profit

On-line poker rooms charge players certain amount to make their profit. This amount is called rake. In cash games, the rake is usually around 5% from each pot and the maximum rake height per one hand is limited by the poker room (otherwise, the rake would be too high in high stakes cash games). In tournament play, the rake is fixed and deducted from player's account in the process of registration. It is usually 10% from the buy-in fee.

Even though you are a winning player, the rake still harms your win rate. For this reason, many poker rooms offer V.I.P. statuses for loyal players which ease the rake effect on their bankrolls. Players then for example collect points for played games and the points can be later redeemed for real money or useful poker merchandise.

3.3 Legal issues of on-line poker

From legal perspective, on-line poker is usually categorized as an on-line gambling. In some countries there is a special law regulating on-line poker but very similar principles apply. In the Czech Republic the on-line and live poker is considered gambling and falls under lottery law. It means that poker can be played only in licensed virtual or regular casinos. This fact led to a recent shutdown of many popular poker clubs all over the Czech Republic because the clubs did not have proper licensing. The outraged players were forced to move to casinos. On the other hand, the Czech Ministry of Finance is currently working on a new amendment regarding poker, so there may be a brighter poker future for the Czech players. The law should be proposed to the government no later than in July 2014.⁷

3.3.1 Taxes

Many players playing on-line poker believe that they are not obliged to pay taxes as long as they are not playing professionally. The truth is that basically all the money won in

⁷ HEDBÁVNÝ, Jan. Česká republika připravuje nový loterijní zákon. [online]. 2013, 28.11.2013 [cit. 2014-03-09]. Available at: <http://www.pokerzive.cz/zpravodajstvi/novinky/ceska-republika-pripravuje-novy-loterijni-zakon/>

poker is taxable. But it is important to distinguish if you are hobby or professional player. The taxes make difference whether poker is source of livelihood or just a recreational activity. The biggest advantage of filling taxes as a professional player is that you can deduct expenses related to on-line poker (such as poker software and computer hardware). However, it is always advised to players to consult their tax statements with certified accountant or other tax professional. Also, it is important to keep tournament records and overview of winning and losing sessions in case of necessity.

3.3.2 Black Friday

Black Friday of poker, also known as the case “United States v. Scheinberg” is a lawsuit by the United States against three largest poker companies Pokerstars.com, Fulltilt poker, Absolute poker and their associates. The defendants were alleged of criminal money laundering and bank fraud. The prosecution came down on Friday April 15, 2011. From this point the Department of Justice took control over the defendant’s websites and froze about 76 accounts in 14 countries. Players were not only unable to play on the site, but also they were not allowed to withdraw their funds.

Pokerstars and Fulltilt later regained control of their domains in order to pay out the U.S. players. Pokerstars were able to redeem players from a separate account but Fulltilt failed to reimburse their players because the company was running on illegal Ponzi scheme and the owners stole more than 440 million⁸ dollars of the customer money. U.S. government later put into effect the UIGEA (Unlawful Internet Gambling Enforcement) legislation which *"prohibits gambling businesses from knowingly accepting payments in connection with the participation of another person in a bet or wager that involves the use of the Internet and that is unlawful under any federal or state law."*⁹ It means that UIGEA does not directly prohibit on-line poker playing but it makes illegal to receive funds from gambling sites. This law made the on-line poker illegal in the United States.

In July 2012, Pokerstars arranged to buy Fulltilt under the condition of

⁸ BENNETT, Dashiell. *Full Tilt Poker Accused Of Stealing \$440 Million Of Players' Winnings In Giant "Ponzi Scheme"* [online]. 2011, 2011-09-20 [cit. 2014-03-09]. Available at: <http://www.businessinsider.com/full-tilt-poker-stealing-players-winnings-2011-9>

⁹ Federal government of the United States. Unlawful Internet Gambling Enforcement Act of 2006. In: US Government, 2006. Available at: <http://www.fdic.gov/news/news/financial/2010/fil10035a.pdf>

compensating all their players. The deal was approved by the U.S. Federal government and charges against these two sites were dismissed. Criminal charges related to bank frauds and money laundering against individuals such as Isai Scheinberg (founder of Pokerstars) or Raymond Bitar (CEO of Fulltilt) remained in effect and has yet to be solved.

Absolute poker was mainly focused on American customers so this case completely destroyed their business. Pokerstars and Fulltilt had large bases of real money players throughout the world, so they were able to continue in successful operating.

3.4 Mathematical aspects of poker

Poker is a game full of odds, probability and fast decisions. It is a game about managing money, thus good players have to be able to estimate their chances of winning the pot and correctly assess the degree of risk when they're investing their money. *"Odds give you the bad news up front, in unavoidable black and white; they are brutally honest."*

¹⁰ The odds are written as a ratio. *"By convention, the first number states how many times something will not happen, while the second number states how many times it will happen. Usually the second number is reduced to 1. If the odds are known, the probability can easily be calculated and vice versa. Probability, as relates to Hold'em poker, tells the player the chances of an event happening in terms of a fraction, a number, or a percentage."* ¹⁰ Sometimes it is more suitable to use odds, sometimes it is more convenient to use the chances expressed in percentage.

All of the mathematical computations in this chapter relate to Texas hold'em poker.

3.4.1 Pot odds

"The single most important factor in deciding whether to call a bet is the odds offered by the pot. This is like any other investment: To know whether you should accept a certain risk, you must also know the corresponding reward. Pot odds are defined as the size of the pot (your reward) divided by the size of the bet (what you must risk)." ¹¹ Generally, the lower the pot odds are, the more suitable is to fold your card and give up the

¹⁰ PETRIV, Mike. *Hold'em's odd(s) book*. 1st ed. Toronto, Ont: Objective Observer. ISBN 09-681-2230-2.

¹¹ MOSHMAN, By Collin. *Sit 'n go strategy: expert advice for beating one-table poker tournaments*. 1st ed. Henderson, NV, 2007. ISBN 978-188-0685-396.

game. In order to make a good decision, player also needs to know how to count its hand outs, compute hand odds and calculate the expected value.

$$\textit{Pot odds} = \textit{Total pot size} : \textit{bet to call}$$

Formula 1: Pot odds¹¹

3.4.2 Hand outs

Hand outs are all available unseen cards that help player create a combination which is likely to win. Knowing the exact number of outs is a crucial part of a good poker strategy. Outs can be easily converted to the probability and help players estimate their chances of winning.

3.4.3 Hand odds

Hand odds are defined as a number of all unseen cards minus outs, divided by outs. Hand odds can be expressed in percentage or ratio in x:1 format or in percentage. Since it can be hard to make such computations in a short time, players often use so called 4-2 rule which advise to multiply number of outs by 4 after the flop or by 2 after the turn in order to get hand odds quickly in percentages. So, if player holds combination which has 7 outs after the flop, the estimated chance of winning is 28%.

$$\textit{Hand odds} = \frac{\textit{Number of unseen cards} - \textit{outs}}{\textit{Number of outs}}$$

Formula 2: Hand odds¹⁰

3.4.4 Expected value

The concept of expected value tells us what average profit or loss the player can expect in a particular game. Acronym EV+ indicates a profitable game in which we expect long-term money gain. The EV- stands for a long-term losing of funds. It is obvious that main objective of every good player is to participate in games with the highest expected value. The basic calculation of poker EV consists of multiplying all possible results of a specific game according to their probability of occurrence and their subsequent comparison. This definition may look very complicated, but in fact, the computation is

very simple.¹²

$$EV = \sum x_i p_i$$

Formula 3: Expected value¹³

The " x_i " in the formula stands for a possible outcome and the " p_i " represents its probability of occurrence.

3.4.5 Variance

Variance in statistics and probability theory is described as a measure of spread of sample from its expected value. It is an indicator of how close the data are to the mean. In this thesis, author is using variance of discrete random variable, because poker is a game of random occurrence. It is defined by:

$$\sigma^2 = \sum p_i (x_i - \mu_x)^2$$

Formula 4: Variance of a discrete random variable¹³

In this formula, the " x_i " represents possible outcome, " μ_x " is the mean or average and " p_i " stands for probability of occurrence.

Since poker is a game with an element of chance, the concept of variance is used here to denote the player's deviation from the expected profit. This element is the main reason why some people think that poker is a game of luck. But it is just a misunderstanding of variance. It can happen that good player loses many times in a row while inexperienced beginner has a winning streak but poker players have to accept variance as a fact and be patient. It is important to realize that it doesn't matter whether the player wins particular game or not, the most relevant thing is to make a good long-term decision. Because in a long-term variance is suppressed and results (earnings) get closer to average (expected) profitability.

¹² LITTLE, Jonathan. *Secrets of professional tournament poker*. Hove, UK: D. ISBN 978-190-4468-561.

¹³ HENDL, Jan. *Přehled statistických metod zpracování dat: analýza a metaanalýza dat*. Vyd. 2., opr. Praha: Portál, 2006. ISBN 80-736-7123-9.

Variance can be either positive or negative. Positive variance is called upswing (being more in profit than expected) in poker terms and the negative is downswing (losing more money than expected). But *"there is one problem with the variance as a measure: it gives a measure in units squared."*¹⁴ Which in some cases make only little sense because when you for example compute variance of number of friends, the result is then in friends squared which is trivial. So we often use square root of variance and this measure is known as the standard deviation.

3.4.6 Standard deviation

In statistics and probability theory, standard deviation represents how much dispersion from the average exists. In other words, it is a measure of how much spread out numbers are from the mean. Standard deviation is the square root of variance. *"A small standard deviation (relative to the value of the mean itself) indicates that the data points are close to the mean. A large standard deviation (relative to the mean) indicates that the data points are distant from the mean."*¹⁴

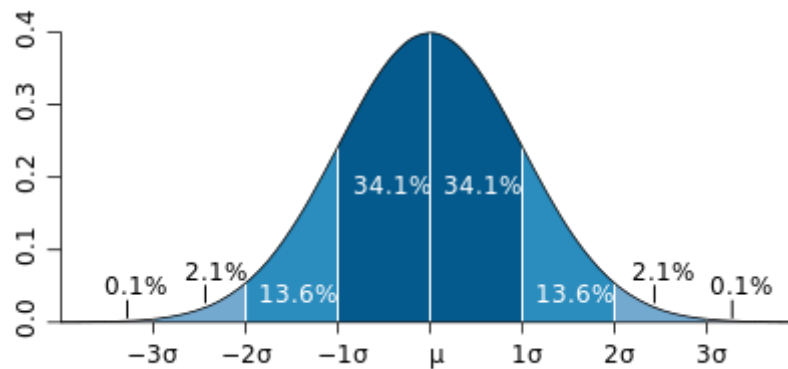
$$\sigma = \sqrt{\sum p_i (x_i - \mu_x)^2}$$

Formula 5: Standard deviation¹⁴

3.4.7 Normal distribution

Normal distribution (or Gaussian distribution) is a function representing the distribution of random variables around the mean as a symmetrical bell-shaped graph. This shape implies that the majority of scores lie around the centre (mean) of the distribution. And as we get further away from the centre, the graph indicates that as the scores start to deviate from the mean their frequency is decreasing. Also, normal distribution tells us that 68.3% of the variables are within 1 standard deviation, 95.4% are within 2 deviations and 99.7% values fall within 3 standard deviations.¹⁴

¹⁴ FIELD, Andy. *Discovering Statistics Using IBM SPSS Statistics*. 4. ed. London: Sage Publications Ltd, 2012. ISBN 14-462-4917-4.



Picture 12: Normal distribution bell-curve

Source: en.wikipedia.org

3.5 Poker tools

Poker tools are software or web based applications which help players to record their own statistics, statistics of other players, convert hands from on-line cardroom hand history files or simply calculate hand odds in desired situation. It helps players to improve their game and see its own leaks and mistakes.

3.5.1 Odds calculators

Poker odds calculators are algorithms which derive chances of winning, losing or draw of any card combination through probability. User can set up any game scenario including number of players, game type being played, available cards and find out the chances of winning.

Providers: Pokerstove calculator, Pokerstrategy.com Equilab software

3.5.2 Hand converters

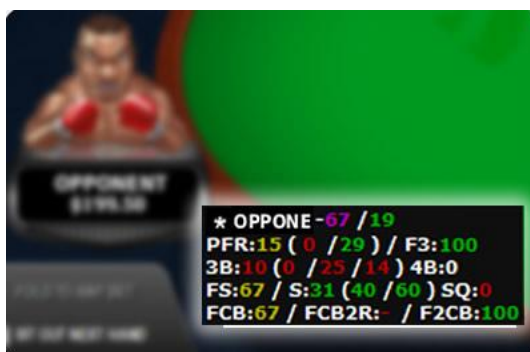
Hand converters allow user to transform chaotic text hand history saved from on-line card room into more eye friendly format. Players use converters to replay and revise their games, share them on-line on social networks or with other players to discuss and analyse. It is a great way how to track own performance and detect mistakes. In addition, the hand history can be stored to gather statistical data about opponents.

Providers: Pokerhandreplays.com, cardrunners.com hand converter

3.5.3 HUD programs

HUD is an acronym for heads up display. HUD programs import hand history files

into database and display the statistics directly on the virtual on-line table in a form of small box with numbers. This software is accepted by most of the major on-line poker providers. The HUD programs allow user to make a quick overview about opponent by showing his or her statistics such as pre-flop raise, voluntarily put money into the pot, aggression factor, frequency of re-raise and many more. In addition, the software usually offers various graphs and hand history analysis. The order and choice of the statistics in the box can be adjusted to the user's taste.



Picture 13; HUD statistics box

Source: parttimepoker.com

Providers: Hold'em manager, Poker tracker, Poker-Edge

3.6 *Poker statistics*

Poker is a game of incomplete information. But by observing various signs, we can quite accurately estimate how we stand in the game. By considering the opponent's behaviour, the height of bet structure in betting rounds and by his actions (check, bet, raise, re-raise) we can reckon our chances, estimate opponent's card range and distinguish who are we playing against. Strong players play only fewer card combinations and bet aggressively. Weak player usually plays many combinations and easily gives up, maniac players bet aggressively and barely fold.

Therefore it is crucial to observe everyone at the table in order to get information about players and take an advantage of it. This can be achievable when you play at one table, but since the biggest advantage of on-line poker from classic live poker is that players can register into several tournaments, they usually play on many tables at one time. Then, it is getting more complicated to observe opponents on several opened tables, plus the time for decision is shorter. For this reason, players very often use the HUD software to

simplify their decisions. This chapter explains the basic selection of widely used heads-up display statistics. All the statistical formulas in this chapter are derived from the Hold'em manager 2 software.

3.6.1 Pre-flop statistics

The quickest way how to identify player is by observing so called pre-flop stats. It shows percentage of how often player decided for certain action before the rest of the cards are dealt on the table (community cards). There are many statistics that player or software can record but most important pre-flop stats to watch are voluntarily put money in the pot, pre-flop raise and pre-flop re-raise.

3.6.1.1 Voluntarily put money in the pot (VPIP)

VPIP represents a percentage of how often player voluntarily participates in the game. This fundamental statistic includes call, raise or re-raise of the big blind bet. It gives us an idea of the range of the starting hands with which are opponents willing to play. Every time a player raises or calls, the VPIP increases. The small blind and big blind bets do not count toward VPIP because these bets are obligatory bets, therefore they are not put voluntarily. Most winning players have VPIP value between 18% and 35% but some players might have a different value and still be profitable.

$$VPIP(\%) = \frac{\text{Number of times money were put voluntarily in the pot}}{\text{Total number of hands played}} * 100$$

Formula 6: Voluntarily put money in the pot

In the picture below we can see a 100% VPIP (all possible card combinations that can be dealt to a player). The letter "s" stands for suited, meaning two cards of the same colour. The "o" means off-suit as two cards of different suit.

Card matrix													
AA	AKs	AQs	AJs	ATs	A9s	A8s	A7s	A6s	A5s	A4s	A3s	A2s	
AKo	KK	KQs	KJs	KTs	K9s	K8s	K7s	K6s	K5s	K4s	K3s	K2s	
AQo	KQo	QQ	QJs	QTs	Q9s	Q8s	Q7s	Q6s	Q5s	Q4s	Q3s	Q2s	
AJo	KJo	QJo	JJ	JTs	J9s	J8s	J7s	J6s	J5s	J4s	J3s	J2s	
ATo	KTo	QTo	JTo	TT	T9s	T8s	T7s	T6s	T5s	T4s	T3s	T2s	
A9o	K9o	Q9o	J9o	T9o	99	98s	97s	96s	95s	94s	93s	92s	
A8o	K8o	Q8o	J8o	T8o	98o	88	87s	86s	85s	84s	83s	82s	
A7o	K7o	Q7o	J7o	T7o	97o	87o	77	76s	75s	74s	73s	72s	
A6o	K6o	Q6o	J6o	T6o	96o	86o	76o	66	65s	64s	63s	62s	
A5o	K5o	Q5o	J5o	T5o	95o	85o	75o	65o	55	54s	53s	52s	
A4o	K4o	Q4o	J4o	T4o	94o	84o	74o	64o	54o	44	43s	42s	
A3o	K3o	Q3o	J3o	T3o	93o	83o	73o	63o	53o	43o	33	32s	
A2o	K2o	Q2o	J2o	T2o	92o	82o	72o	62o	52o	42o	32o	22	

Picture 14; all possible card combinations

Source: Equilab software output

3.6.1.2 Pre-flop raise (PFR)

Pre-flop raise records with how many percent of the starting hands is our opponent willing to raise before the flop. It is a more specific version of VPIP. So, every time player enters the pot with pre-flop raise it is counted toward PFR statistic. Good players usually have VPIP and PFR values very close together. For example players with 22% VPIP and 19% PFR.

$$PFR(\%) = \frac{\text{Number of raised bets}}{\text{Total number of hands played}} * 100$$

Formula 7: Pre-flop raise

3.6.1.3 Attempt to steal (Att to Steal)

Attempt to steal is a statistic that records how often a player tries to steal small blind and big blind bets from the cut-off, button and small blind positions. From these positions, players very often try to steal the mandatory bets even with weak hand combinations (if there was no action ahead of them) because the stealing player can be sure that it will have the advantageous position of being second to act on the flop and alternatively on the turn and river. Good winning players playing tournaments with quick blind structure have this statistic about 40%.

$$\text{Att to Steal}(\%) = \frac{\text{Number of raises from CO, button and SB}}{\text{Number of opportunities to steal}} * 100$$

Formula 8: Attempt to steal

3.6.1.4 Pre-flop re-raise (3bet)

Pre-flop 3bet extends the PFR statistic and captures any additional raise of previously raised bet. In other words, 3bet is a situation when there has been a raise and then another raise after that occurred. It is an absolutely essential weapon for every good player. We can distinguish between classic 3bet with good hand combination when we re-raise the bet for value. Other case is so called 3bet light when we re-raise with weak combination in order to scare opponent, forcing him to fold his cards and give up the game. Players with 3bet lower than 3% are usually too cautious and good players can easily overplay them.

$$\text{3bet}(\%) = \frac{\text{Number of re - raised bets}}{\text{Number of opportunities to re - raise}} * 100$$

Formula 9: Pre-flop re-raise

3.6.1.5 Fold to re-raise (Fold to 3bet)

As it is obvious from the heading, this statistic is focused on frequency of opponent's folds when the bet is re-raised by other player.

$$\text{Fold to 3bet}(\%) = \frac{\text{Number of folds to 3bet}}{\text{Number of 3bets}} * 100$$

Formula 10: Fold to re-raise

3.6.2 Post-flop statistics

Post-flop statistics are no less important than the pre-flop stats. These figures record the player's action after the first three community cards has been dealt on the table. Again, the collected data serve to easy and simplify decision during the game. It is important to well interpret these numbers and then respond with appropriate action.

3.6.2.1 Continuation bet (Cbet)

"A continuation bet occurs when you took the lead in the betting pre-flop, indicating strength, you missed the flop, and now you are in position to make the first bet

after the flop, either because you're first to act or because the players have all checked to you." ¹⁵ In other words the Cbet statistic records how often a player has chosen to continue in betting after he or she previously raised the pot. It is an essential game part of aggressive players. This move can win money without a good combination but players need to be cautious because too frequent continuation bet can be easily spotted by opponents. Cbet is categorized as a semi-bluff which means that sometimes players bet because they actually hit a strong card combination and sometimes they use this move as a bluff. Bad player can be found with an extremely high Cbet values up to 100% or contrarily with values very low. Winning players have continuation bet balanced between 65-85% depending on the style of their game.

$$Cbet(\%) = \frac{\text{Number of cbets}}{\text{Number of seen flops}} * 100$$

Formula 11: Continuation bet

3.6.2.2 Fold to continuation bet (Fold to cbet)

It is evident from the title that this statistic is closely related to the previous one. Fold to continuation bet represents how often a certain player gives up against opponent's cbet. According to this stat, players can adjust their frequency of continuation bet. Against players who have a high fold to cbet, it is recommended to use continuation bet very often and on the contrary, against players with low Fold to cbet percentage, it is advised to continue in betting only for value.

$$Cbet(\%) = \frac{\text{Number of folds to cbet}}{\text{Number of opportunities to fold to cbet}} * 100$$

Formula 12: Fold to continuation bet

3.6.2.3 Aggression frequency (AFq)

The aggression frequency tells us how much a player is aggressive in overall. It is calculated as a frequency of aggressive actions (bet, raise) divided by aggressive and passive actions (check, fold, call). This statistic is a successor of total aggression statistic which was popular before but it didn't take into account the fold action which means that it

¹⁵ HARRINGTON, Dan a Bill ROBERTIE. *Harrington on hold 'em: expert strategy for no-limit tournaments*. 1st ed. Henderson, Nev.: Two Plus Two Pub., 3 v. ISBN 18806853613.

was not an entirely accurate measurement of aggression. The aggression frequency can be divided into three statistics and be measured separately on the flop, turn and river.

$$AFq(\%) = \frac{\text{Number of bets and raises}}{\text{Number of bets, raises, checks, folds and calls}} * 100$$

Formula 13: Aggression frequency

3.6.2.4 Went to showdown (WTSD)

WTSD captures how often a player gets to showdown if he gets on the flop. This statistic indirectly shows what the chances are that the opponent gives up the game after the flop and in following betting rounds. It gives player a better idea what strategy to choose in the post-flop game. The lower the WTSD value opponent has, the easier the player can bluff against it. Players with WTSD lower than 20% are considered tight and go to showdown with only strong combinations, while WTSD over 30% is typical for loose players.

$$WTSD(\%) = \frac{\text{Number hands that end up in showdown}}{\text{Number of seen flops}} * 100$$

Formula 14: Went to showdown

3.7 Playing styles

*"One interesting thing of big bet poker is that we can see players use so many different styles. What's especially remarkable is that so many of these styles can be played effectively."*¹⁶ This chapter examines some of the most common styles and looks what makes each style bad or effective. According to the frequency of certain actions we differentiate various types of players and divide them into five theoretical categories according to their way of play. The best way how to identify player is with the use of HUD software. It comes in handy whenever we are sit to a new table with new players and we need to quickly assess who we are playing against. With the help of HUD software statistics, it is possible to categorize players and then come up with proper strategy. It also makes our decisions faster, because we can see the statistics immediately and it is not necessary to recall every previous move of an opponent.

¹⁶ CHRISTENSON, Nick a Russell FOX. *Winning strategies for no-limit hold'em*. 1st ed. ConJelCo LLC, 2008, 204 p. ISBN 978-188-6070-301.

For each player, author provided table with statistics of a real player, specifically statistics of voluntarily put money in pot, pre-flop raise and pre-flop re-raise. The statistics were derived from authors own 50 000 hands history using Hold'em manager 2 software. All the hands were played on pokerstars.com cash game servers in Texas hold'em variant in the years from 2012 to 2014. In order to keep anonymity of players, author did not use their real gaming nicknames and named them Player_1, Player_2, Player_3, Player_4 and Player_5.

Table below represents different fractions of VPIP, PFR and 3bet derived from all of the possible card combinations. It gives a better idea about what card combinations are certain players willing to play, raise or re-raise.

VPIP/PFR/3bet	Starting combinations
3%	99+, AKs
5%	88+, AJs+, KQs, AKo
10%	77+, A9s+, KTs+, QTs+, AJo+, KQo
20%	66+, A4s+, K8s+, Q9s+, J9s+, T9s, A9o+, KTo+, QTo+, JTo
35%	55+, A2s+, K3s+, Q5s+, J7s+, T7s+, 97s+, 87s, A4o+, K8o+, Q9o+, J9o+, T9o
50%	33+, A2s+, K2s+, Q2s+, J4s+, T6s+, 96s+, 86s+, 76s, 65s, A2o+, K5o+, Q7o+, J7o+, T7o+, 98o

Table 1: Proportional ranges of starting combinations

Source: own processing in MS word with the use of Equilab software

The "+" sign represents any better combination. So, for example, 88+ stands for all the pocket pairs from two eights and higher. Which basically means two eights, two nines, two tens, two jacks, two queens, two kings and two aces.

3.7.1 Tight passive (The rock)

The tight passive player plays only very few starting hands and only rarely bets or raises a bet. If this player is in the game it is very likely that it is holding a strong card combination. This player also only rarely bluffs and plays fearfully. Limitation of his card range and passive play can lead into loses from medium strong cards. *"Very tight players*

will win less than their fair share of pots, but they gain by playing only in those situations in which they have a substantial edge." ¹⁶ Aggressive players easily force this type of a player to fold his or her cards. On the other hand, this player doesn't necessarily waste money on garbage hands, raises with only high value combinations and plays with minimum risk.

Player_1	
VPIP	15
PFR	5
3bet	3

Table 2: Tight passive player

Optimal strategy against this player is to increase your betting frequency and take down the pot every time when the opponent seems passive. This type of player is easy to bluff and you can very often steal the blind bets from him or her even with poor combinations. Since this player is willing to play only high value combinations, it is essential to bet or raise whenever the board brings cards of low value, because the opponent most likely did not improve his or her combination. Be cautious whenever this player shows aggression, post-flop bets are probably representing true strength.

3.7.2 Loose passive (The calling station)

The calling station is a player who likes to play many starting combinations but only rarely raises. This kind of player prefers calls and checks instead of other aggressive moves. This style is usually played by beginners or not very skilled players who call the bet with almost any two cards in order to see what the flop brings. Even if the loose passive player misses the flop it calls bets anyway, hoping to catch a card which is most likely not going to be dealt because of low probability. With strong card combination, the loose passive player is afraid to raise or bet properly because it is afraid of scaring his opponents out of the game. As well as the tight passive, the calling station player loses money by not getting maximum profit from the good hands, plus it is not able to protect his combinations by its passive actions.

Player_2	
VPIP	48
PFR	7
3bet	2

Table 3: Loose passive player

The best strategy against this player is to bet only with good hands. There is no sense of bluffing since this player likes to call bets. Try to get more value from your strong combinations by betting higher if the loose passive player is in the game. If a calling station player bets, we should fold even medium strong cards. If you have a drawing hand (hand which has a real chance of improving its value) like flush draw or straight draw, it is a good idea to check because the passive player will often check as well and you will end up with a free card to see.

3.7.3 Tight aggressive (TAG)

Tight aggressive players tend to play only few starting hands but usually very aggressively. It means that they enter the game with a bet or raise and don't call the very often. *"When a player bets or raises, it forces the opposition to make decisions. When they're forced to make decisions it gives them an opportunity to make mistakes. We make money when our opponents make mistakes, so we should give them every opportunity to do so."*¹⁶ By the combination of tight opening card range and aggressiveness a TAG player can either win by holding the best hand or it can make the opponents fold. Many profitable professionals are classified as tight aggressive therefore this strategy can be very successful when played properly. But on the other hand, TAG players get easily seen through by opponents since they play only very few combinations. Also there is a risk of losing big pots of money when tight aggressive player has a strong cards but not as strong as opponent. An example of successful tight aggressive player is a thirteen times WSOP champion Phil Hellmuth.

Player_3	
VPIP	23
PFR	19
3bet	7

Table 4: Tight aggressive player

The best strategy is to avoid these players if possible. Even if you are able to outplay them, your win rate will be smaller than when you play against weaker players. But sometimes there is no possibility of sitting somewhere else (for example in tournament play, where the seating is given and there is no possibility to move). In this case, try to spot inferior players at the table and try to play more hands against them. When you get into confrontation with TAG player, play only from good positions or with strong combinations. Since this player is willing to play only limited card range it is essential to increase aggression whenever the board brings card of low values because there is a big probability that our opponent has missed it. With a good hand on the flop, you can try to pull out check-raise move on the flop because the tight aggressive players tend to bet whenever they see sign of passivity. Plus it is a good idea to steal blinds from TAG player because it is used to defend his blind bets with only strong hands.

3.7.4 Loose aggressive (LAG)

*"This style of play has become more popular in recent years, especially among a generation of internet-trained poker professionals. The idea here is to play aggressively, but to play relatively large number of hands. If successful, such a player may lose a fairly large number of small pots, but should make up for it by winning more than their fair share of large pots. A successful loose aggressive player is playing a lot of hands, taking down pots that nobody else wants, and then getting paid off with his big hands because his opponents have no idea where he's at."*¹⁶ And it is extremely hard to read or estimate LAG player's card range. He or she can also intimidate opponents or make them sometimes wrongly assume that he or she is bluffing. Examples of well-known loose aggressive professional players are Phil Ivey, Viktor Blom or Tom Dwan.

Player_4	
VPIP	35
PFR	29
3bet	13

Table 5: Loose aggressive player

An effective strategy when playing against loose aggressive player, is to play from good positions as much as possible. It is a big advantage to see first how the LAG player reacted. Generally it is not recommended to make a lot of continuation bets against this kind of players, because they don't fold their hands very often so it would be a waste of money. A good point is that you don't need a very strong combination to be pre-flop favourite against this player because it has a wide range of starting hands. It is relevant not to get intimidated by the aggressive bets. And it is crucial to raise or even re-raise LAG player with strong hand combinations and gain the maximal value from premium hands.

3.7.5 Maniac

Maniac is an extremely aggressive and loose player. Even more than LAG players. They play very wild and their presence might influence the dynamic of the whole table. They are involved in majority of hands and their moves very often do not make much sense. Sometimes, maniacs could be decent players who are having bad losing streak and play extremely aggressively because they are in anger. The player participates in too many hands and in a long run, it is almost impossible for him or her to stay in profit.

Player_5	
VPIP	78
PFR	55
3bet	26

Table 7: Maniac player

It is recommended to sit to the left from the maniac so you have a favourable position against him or her in the most cases. Be patient and wait for medium to strong combinations. Also, it is suitable to raise or re-raise the maniacs with these hands and try to get rid of any other players pre-flop (the maniac is most likely not going to fold after your



raises). Your hand will be much better than opponent's cards on average even if you raise with wider range including any ace combination, any pocket pair or big connectors (two cards of high and close values, for example JQ) . Do not give up after the flop even if your hand has not improved, because the strength of your hole cards should be enough in the most cases. Whenever the maniac player forces you to move all-in, be sure to call with tight range of cards and take into consideration number of other players that can get involved. Be conscious that playing against maniacs can be sometimes very frustrating, because their wild playing style can bring them short term luck and big profit swings. It is important to keep a cool head and wait for opportunities.

4 Analytical part

The analytical part of this thesis is divided into two sections. Both sections are focused on a practical use of knowledge introduced in the literature review. First case is focused on the poker decision-making process, the second case is based on a comparative analysis of two tournaments with different variance.

4.1 *Decision-making process in poker*

This part is focused on the use of basic methods for decision-making in poker. The methods are described and explained in the literature review and now used on a practical example. The following game was derived from author's own poker hand history from pokerstars.com Texas hold'em server. Author's real gaming nick name is substituted with pseudonym Hero. The player can be found midway through a game and it is standing against one opponent. The main objective is to substantiate player's decision with mathematical computation. The situation is set up as follows.

Hero is holding  and the flop and turn has been dealt . At this moment, Hero's card value is only high card ace. But it is evident that his card combination can be significantly improved by completing flush (combination of five cards of the same colour). Opponent bets 5\$ and the total pot is now 25\$. It is Hero's move and it has to decide whether to call the bet or fold his cards. It is assumed that the flush will be a winning combination.

4.1.1 Step 1 - pot odds

Firstly, Hero needs to work out the pot odds to find out whether is this situation worth the call or not. This can be done using formula from the theoretical part.

$$\textit{Pot odds} = \textit{Total pot size} : \textit{bet to call}$$

Formula 15: Pot odds

$$\textit{Pot odds} = 25 : 5$$


$$\textit{Pot odds} = 5 : 1$$

Computation 1

This ratio says that Hero has to win at least one out of six games to remain at zero

profit.

4.1.2 Step 2 - outs

Second step is to calculate the number of cards which can improve Hero's combination. In order to complete the flush, player needs certain card to be dealt on the river. One of those cards is . As you can see, Hero has 9 cards which can improve his hand. It means that the it has 9 outs.

4.1.3 Step 3 - hand odds

Third goal is to assess the probability of completing flush. Once again, we use formula from theoretical part to make our estimation. The number of unseen cards is easy to figure out. Texas hold'em is played with a deck of 52 cards. From this number, we subtract the number of cards dealt on the table (4) and number of cards in Hero's hands (2).

$$\text{Hand odds} = \frac{\text{Number of unseen cards} - \text{outs}}{\text{Number of outs}}$$

Formula 16: Hand odds

$$\text{Hand odds} = \frac{52 - 4 - 2 - 9}{9}$$

$$\text{Hand odds} = \frac{37}{9} \doteq 4.11$$

Computation 2

The hand odds for this situation are 4.11:1 or 19.57% of making the flush combination.

4.1.4 Step 4 - compare pot odds and hand odds

Next step is to compare the pot odds with hand odds. When pot odds are higher than hand odds, it is in terms of statistics recommended to call the bet because in a long-term, player will complete winning combination more frequently than it is required by the pot odds. In this situation, the pot odds (5:1) are higher than hand odds (4.11:1), so the Hero can be sure that calling the bet will be a profitable decision in a long-term. This situation can be marked as a EV+ situation, meaning that Hero can expect winning money. It doesn't matter how the situation ended. The objective is to make a good long-term

decision.

4.1.5 Step 5 - expected value

In order to compute exact expected profit or loss, it is necessary to calculate the expected value of the situation. The probability of completing flush is 19.57% or 0.1957. Therefore the odds of not completing the flush are 80,43% or 0.8043. Possible win is 25\$ and possible loss is 5\$.

$$EV = \sum x_i p_i$$

Formula 17: Expected value

$$EV(USD) = (25 * 0.1957) + (-5 * 0.8043)$$

$$EV(USD) = 4.89 - 4.02$$

$$EV(USD) = 0.87$$

Computation 3

As you can see, the expected value of this situation is 0.87\$. It means that the Hero will win on average in this situation 0.87\$. If he or she played 100 same situations, the expected profit would be 87\$.

4.2 Use of variance in poker

In this chapter, I would like to present the importance of understanding variance in poker. It is demonstrated using comparative analysis of two seemingly similar cases. Both cases were computed by the author and then simulated in Microsoft Excel using functions INDEX and RAND. The situations are made up and represented on an example of two different tournaments. Even though the tournament results were randomly generated, the conception can be used in real poker games because the simulation was based on probability, just as playing poker.

Once again, author named observed player by the pseudonym Hero. The cases were assigned by the author as follows.

Our Hero is planning to play 500 tournament games with a 1\$ buy-in fee in the following month. Since Hero is a competent player he intends to be in profit at least 380\$ when the 500 game session is completed. He has a choice from two different tournament options and needs to decide which one is more suitable for his requirement. It is solely up to him or her to decide which tournament will have better chances of fulfilling desired profit.

4.2.1 Tournament 1

Poker card room sets up a tournament for 6 people with a guaranteed prize pool of 9\$. Players finishing in the first, second and third place win 3\$. Players finishing fourth, fifth and sixth lose 1\$. We assume that Hero is skilled enough to reach the paid places in 1/2 of the tournaments in the long-term average. This case can be compared to a situation where a player is throwing a dice and wins 3\$ every time he throws an even number but loses 1\$ when he rolls an odd number.

4.2.2 Tournament 2

Poker card room sets up a tournament for 6 people with a guaranteed prize pool of 11\$. Player finishing first wins all 11\$. Players finishing second, third, fourth, fifth and sixth lose 1\$. We assume that Hero is skilled enough to reach the paid place in 1/6 of the tournaments in the long-term average. This case can be compared to a situation where a player is throwing a dice and wins 11\$ when he throws a six but loses 1\$ every time he rolls five, four, three, two or one.

4.2.3 Calculation

To find out the average long run profitability of each tournament it is necessary to compute the expected values for both situations for one played tournament. This can be done by applying EV formula from my theoretical part.

$$EV = \sum x_i p_i$$

Formula 15: Expected value

Possible loss in the first case is 1\$ with a 1/2 (50%) probability of losing. Possible winnings are 3\$ with a 1/2 (50%) probability of winning.

$$EV_{Tournament\ 1}(USD) = \left(\frac{1}{2} * -1\right) + \left(\frac{1}{2} * 3\right)$$

$$EV_{Tournament\ 1}(USD) = 1$$

Computation 4

Possible loss in the second case is 1\$ with a 5/6 (\doteq 83.33%) probability of losing. Possible winnings are 11\$ with a 1/6 (\doteq 16.67%) probability of winning.

$$EV_{Tournament\ 2}(USD) = \left(\frac{5}{6} * -1\right) + \left(\frac{1}{6} * 11\right)$$

$$EV_{Tournament\ 2}(USD) = 1$$

Computation 5

As you can see the tournaments have the exact same expected value of 1\$ for one game, meaning that expected value for 500 tournaments is 500\$. Which means that both cases should be equally profitable in an infinite long-term period. But our Hero is willing to play only 500 games so it is needed to estimate profit swings caused by the variance in the required term. This can be done using discrete random variable variance formula from literature review above.

$$\sigma^2 = \sum p_i(x_i - \mu_x)^2$$

Formula 16: Variance of a discrete random variable

In this example, the mean is the above computed expected value because it represents an average winning for one game.

<p><u>Tournament 1</u></p> $\sigma^2 = \frac{1}{2} * (-1 - 1)^2 + \frac{1}{2} * (3 - 1)^2$ $\sigma^2 = 4$ $\sigma^2_{500 \text{ tournaments}} = 500 * 4$ $\sigma^2_{500 \text{ tournaments}} = 2\,000$		<p><u>Tournament 2</u></p> $\sigma^2 = \frac{5}{6} * (-1 - 1)^2 + \frac{1}{6} * (11 - 1)^2$ $\sigma^2 = 20$ $\sigma^2_{500 \text{ tournaments}} = 500 * 20$ $\sigma^2_{500 \text{ tournaments}} = 10\,000$
--	--	--

Computation 6¹⁷

Another step is to calculate the square root of variance and get the standard deviation.

$$\sigma = \sqrt{\sum p_i(x_i - \mu_x)^2}$$

Formula 17: Standard deviation

$$\sigma = \sqrt{2\,000}$$

$$\sigma \doteq 45$$

$$\sigma = \sqrt{10\,000}$$

$$\sigma = 100$$

Computation 7

Now we are able to predict how much Hero's profit might differ from the expected value. According to the normal distribution we can say that in 68.3% the profit will be within 1 standard deviation, in 95.4% it should be within 2 deviations and in 99.7% the profit will fall between 3 standard deviations.

<p style="border: 1px solid black; display: inline-block; padding: 2px;">With 68.3% certainty</p>		<p style="border: 1px solid black; display: inline-block; padding: 2px;">With 68.3% certainty</p>
Profit = EV ± σ		Profit = EV ± σ
Profit = 500 ± 45		Profit = 500 ± 100
Profit _{max} = <u>545</u> ; Profit _{min} = <u>455</u>		Profit _{max} = <u>600</u> ; Profit _{min} = <u>400</u>
<p style="border: 1px solid black; display: inline-block; padding: 2px;">With 95.4% certainty</p>		<p style="border: 1px solid black; display: inline-block; padding: 2px;">With 95.4% certainty</p>

¹⁷ HORÁK Lukáš, [lukashorak]. (2011, April 4). Poker Texas holdem - Sit and Go -Variance [Video file]. Retrieved from: <http://old.stream.cz/uservideo/566471-poker-texas-holdem-sit-and-go-variance>

$$\text{Profit} = \text{EV} \pm 2\sigma$$

$$\text{Profit} = 500 \pm 90$$

$$\text{Profit}_{\max} = \underline{590}; \text{Profit}_{\min} = \underline{410}$$

With 99.7% certainty

$$\text{Profit} = \text{EV} \pm 3\sigma$$

$$\text{Profit} = 500 \pm 135$$

$$\text{Profit}_{\max} = \underline{635}; \text{Profit}_{\min} = \underline{365}$$

$$\text{Profit} = \text{EV} \pm 2\sigma$$

$$\text{Profit} = 500 \pm 200$$

$$\text{Profit}_{\max} = \underline{700}; \text{Profit}_{\min} = \underline{300}$$

With 99.7% certainty

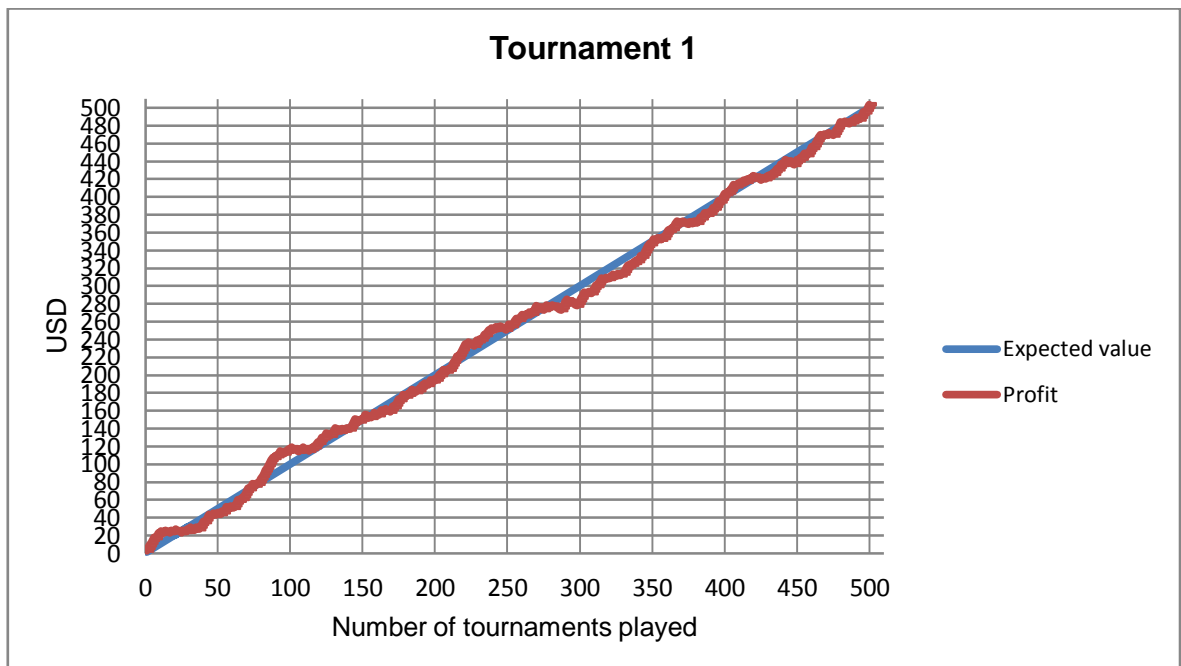
$$\text{Profit} = \text{EV} \pm 3\sigma$$

$$\text{Profit} = 500 \pm 300$$

$$\text{Profit}_{\max} = \underline{800}; \text{Profit}_{\min} = \underline{200}$$

Computation 8

The two graphs below represent Hero's random results in both tournaments after 500 played games. The profit could fall anywhere between the computed ranges above but those are the results of one time simulation. In Tournament 1 Hero ended up winning 508\$, in Tournament 2 Hero won 388\$ after 500 played games.



Graph 2: Tournament 1; Expected value and profit

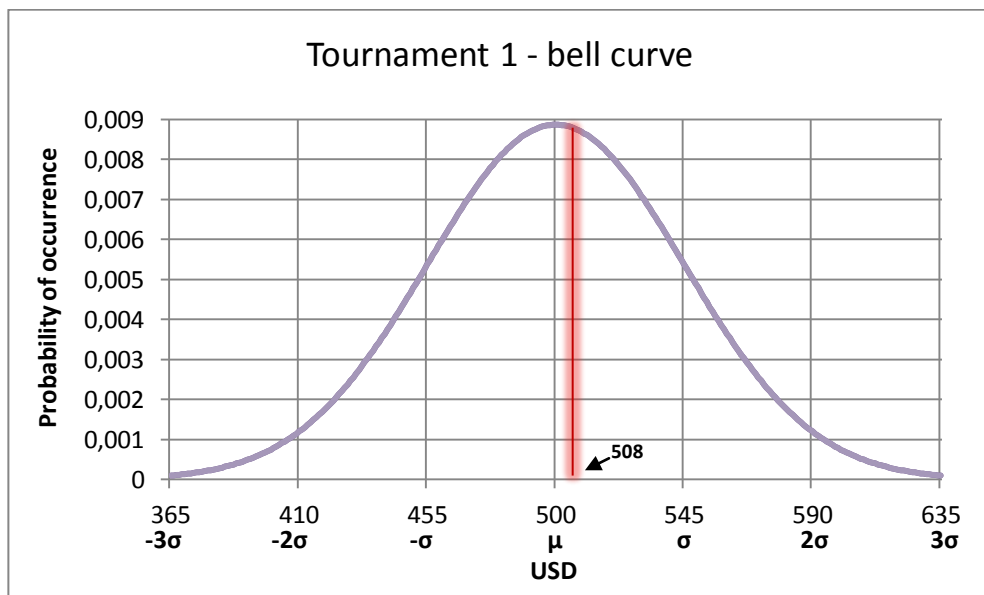
Source: own simulation in MS Excel



Graph 3: Tournament 2; Expected value and profit

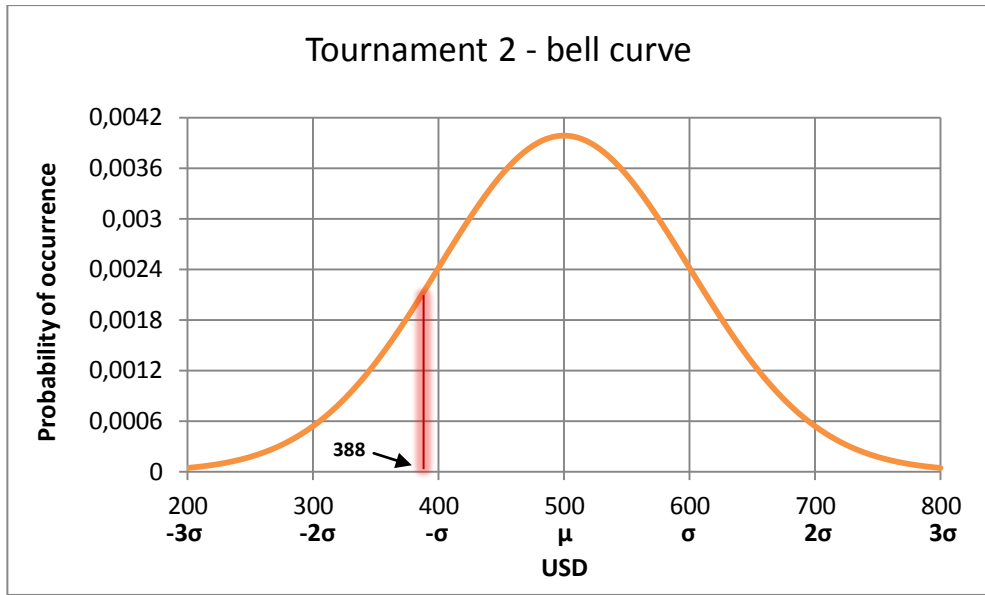
Source: own simulation in MS Excel

The second graph confirms the calculation that Tournament 2 has bigger variance because there are obvious upswings and downswings from the mean while the profit line in the first graph almost copies the expected value. Lastly, bell curves were created for each tournament to see where the simulated results fall in normal distribution.



Graph 4: Tournament 1 bell curve

Source: own processing in MS Excel



Graph 5: Tournament 2 bell curve

Source: own processing in MS Excel

5 Evaluation of results

5.1 Decision-making process in poker - results

In the first chapter of my analytic part we could see the process of decision-making on a particular game example. It shows an easy mathematical way how can players come up with correct decision when they are in a difficult spot. In order to find whether the game was worth investment, pot odds and hand odds were computed and subsequently compared.

The particular case ended up being worth the investment because the pot odds (5:1) were higher than the hand odds (4.11:1). Meaning that in a long-term, player will complete winning combination more frequently than it is required by the pot. Lastly, expected value was computed for given situation in order to find the exact profit amount that player can expect. It was computed that the player will win on average 0.87\$ in the one particular game.

5.2 Use of variance in poker - results

The second chapter of my practical part is focused on understanding statistical variance in poker tournaments. It was important to show that the element of luck in tournament play can be expressed statistically and that the variance can be suppressed by appropriate game selection. And even good, winning players should expect big swings in their profits if they chose to play games with high variance.

It was computed that in Tournament 1 our Hero could expect that his or her profit after five hundred played games will fall with very high probability (99.7%) between 635 and 365 dollars. Both of these numbers are relatively close to the expected mean of 500\$. The one time simulation showed that in the end the Hero was quite fortunate and his results fall within one standard deviation which is normal in 68.3%. The profit stopped on 508\$ after 500 played tournaments and the tournament progress basically copied the expected value throughout the whole time.

Tournament 2 has much higher variance and the results could fall with very high

probability (99.7%) anywhere between 800 and 200 dollars. These numbers are quite far from the expected mean of 500\$ and if the Hero wanted to get closer to the expected value it would be necessary to play more than 500 tournaments. The one time simulation showed that our Hero ended up winning 388\$ meaning that his profit falls within 2 standard deviations which is normal in 95.4%. But the tournament progress was somewhat wild. We can see from the graph that the Hero's winnings were above the expected profit whole time until 300 games played and variance caused big upswing in his earnings. Between 300 and 415 played games the player's gains were close to the mean, but then, the variance caused shorter downswing and the Hero finished below the expected value.

Since the request of the Hero was to win at least 380\$ when the session is completed, it is recommended to him or her to choose the first tournament because it was calculated that it is almost one hundred percent certain that his profit will be minimally 365 dollars. The first tournament has low variance and the results will always be fairly close to the mean. The second tournament is intended for players who don't mind great swings in their earnings (which can be sometimes very frustrating but on the other hand sometimes very pleasant when the winnings exceed the average) or for players who are able to play many of these tournaments in short time and so cut down the impact of variance.

6 Conclusion

The main goal of this thesis was to analyse on-line poker games and prove the hypothesis that poker games are not purely based on luck. The literature review deals mainly with the partial goals, specifically with the rules of poker games, current on-line poker situation in the world, characterizes poker software and its providers, describes different playing styles and discusses the basic mathematical and statistical aspects of this game.

The analytical part demonstrates the use of poker mathematics in decision-making and discusses the role of variance in game options. The first part of the analytical work shows the procedure and computation of poker probability odds on a practical example. Also, it demonstrates that decisions of players can be justified by mathematical calculation, meaning that players can influence their profit rate by correct risk assessment.

The second section is focused on the role of variance in tournament selection. This part shows that game selection can have a significant impact on expected winnings. Also, the element of luck was represented as a common mathematical variance and indicates that being lucky or unlucky depends on statistical normal distribution and not coincidence. Since the main and partial goals were fulfilled and the results of author's analytical prove the impact of player on the game results, the hypothesis of this thesis is accepted.

7 References

7.1 Bibliography

BRUNSON, Doyle. *Online poker: your guide to playing online poker safely*. 1st ed. New York: Cardoza Pub., c2005. ISBN 15-804-2132-6

CHRISTENSON, Nick a Russell FOX. *Winning strategies for no-limit hold'em*. 1st ed. ConJelCo LLC, 2008, 204 p. ISBN 978-188-6070-301.

FIELD, Andy. *Discovering Statistics Using IBM SPSS Statistics*. 4. ed. London: Sage Publications Ltd, 2012. ISBN 14-462-4917-4.

HARRINGTON, Dan a Bill ROBERTIE. *Harrington on hold 'em: expert strategy for no-limit tournaments*. 1st ed. Henderson, Nev.: Two Plus Two Pub., 3 v. ISBN 18806853613.

HENDL, Jan. *Přehled statistických metod zpracování dat: analýza a metaanalýza dat*. Vyd. 2., opr. Praha: Portál, 2006. ISBN 80-736-7123-9.

LITTLE, Jonathan. *Secrets of professional tournament poker*. Hove, UK: D. ISBN 978-190-4468-561.

MOSHMAN, By Collin. *Sit 'n go strategy: expert advice for beating one-table poker tournaments*. 1st ed. Henderson, NV, 2007. ISBN 978-188-0685-396.

PETRIV, Mike. *Hold'em's odd(s) book*. 1st ed. Toronto, Ont: Objective Observer. ISBN 09-681-2230-2.

7.2 On-line sources

BENNETT, Dashiell. Full Tilt Poker Accused Of Stealing \$440 Million Of Players' Winnings In Giant "Ponzi Scheme" [online]. 2011, 2011-09-20 [cit. 2014-03-09]. Available at: <http://www.businessinsider.com/full-tilt-poker-stealing-players-winnings-2011-9>

CAESARS INTERACTIVE ENTERTAINMENT, INC. World Series of Poker. [online]. [cit. 2014-03-12]. Available at: <http://www.wsop.com/>

FEDERAL GOVERNMENT OF THE UNITED STATES. Unlawful Internet Gambling Enforcement Act of 2006. In: SAFE Port Act, 2006. Available at: <http://www.fdic.gov/news/news/financial/2010/fil10035a.pdf>

HEDBÁVNÝ, Jan. Česká republika připravuje nový loterijní zákon. [online]. 2013, 28.11.2013 [cit. 2014-03-09]. Available at: <http://www.pokerzive.cz/zpravodajstvi/novinky/ceska-republika-pripravuje-novy-loterijni-zakon/>

HORÁK Lukáš, [lukashorak]. (2011, April 4). Poker Texas holdem - Sit and Go -Variance [Video file]. Retrieved from: <http://old.stream.cz/uservideo/566471-poker-texas-holdem-sit-and-go-variance>

PARLETT, David. A History of Poker. In: *Card Games: History of Poker* [online]. [cit. 2014-03-09]. Available at: <http://www.pagat.com/poker/history.html#birth-growth>

SMITH, Erik. Poker History: Online Poker Eras. [online]. 2011 [cit. 2014-03-11]. Available at: <http://www.pokerhistory.eu/history/historic-poker-eras>

THEPPA.ORG. U.S. Online Poker Survey 2012. In: [online]. United States: Poker Players Alliance, 2012 [cit. 2014-03-09]. Available at: <http://www.scribd.com/doc/106952469/U-S-Online-Poker-Survey-2012>