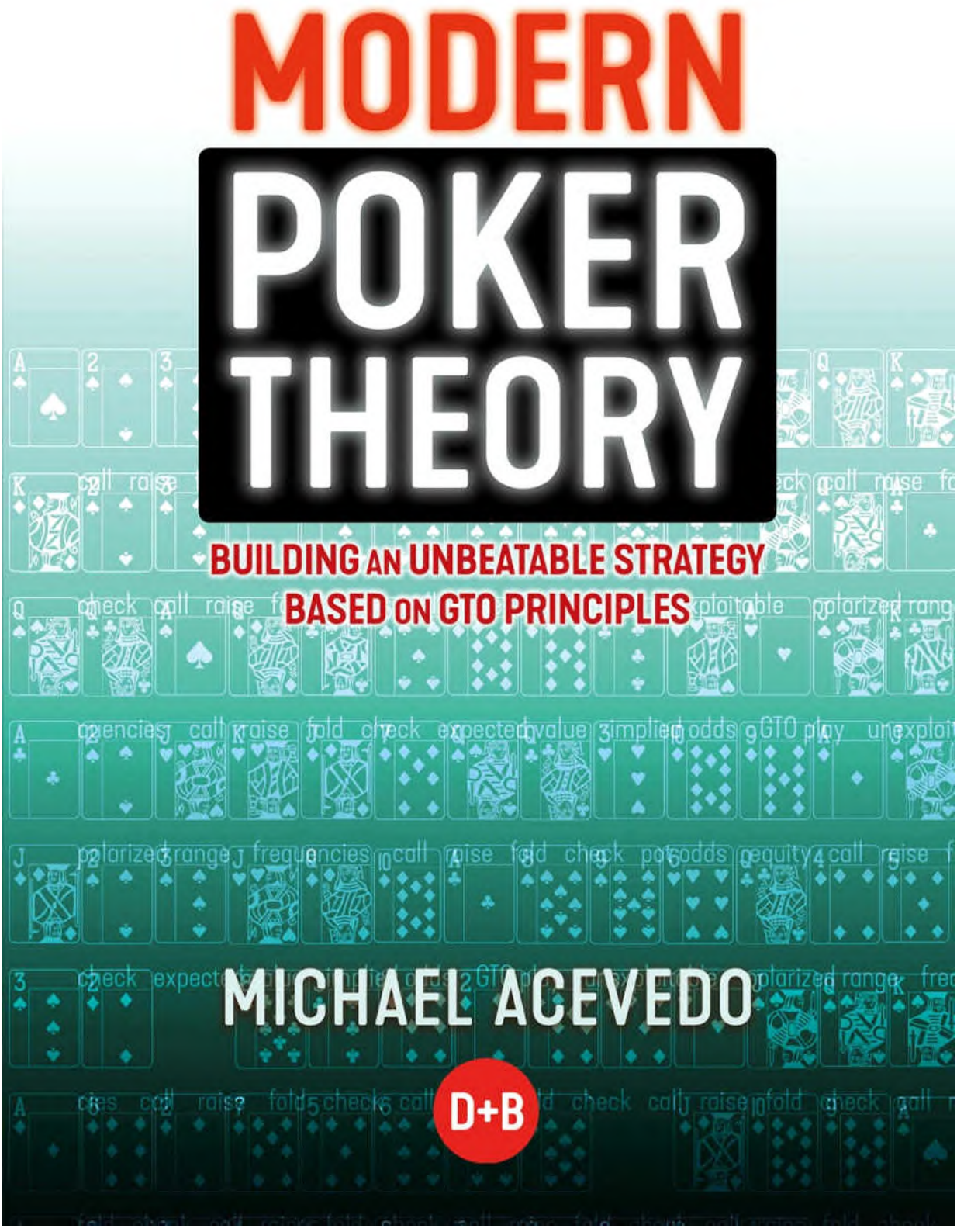
MODERN POKER THEORY

BUILDING AN UNBEATABLE STRATEGY BASED ON GTO PRINCIPLES

MICHAEL ACEVEDO

D+B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Michael Acevedo is a professional online tournament player, coach and leading poker theorist. In 2013 he quit his job as a financial analyst to pursue his dream of becoming a professional poker player. His background as a mathematician and expertise in process improvement helped him master the theoretical aspects of poker. He started playing online professionally in 2014 and has earnt over $1,500,000 in online tournament cashes.

During the last few years Michael has worked alongside some of the brightest minds in modern poker, including WSOP bracelet winner Martin ‘Nizmojiz’ Kozlov, WCOOP bracelet winner and PLO coach Fernando ‘jnandez87’ Habegger and the living legend, three-time triple crown winner and author, Jon ‘Apestyles’ Van Fleet. Michael makes educational poker videos and content for training websites and staking groups including pocarr.com and coaches hundreds of players from around the world. He has become one of the most recommended tournament coaches in the pocketfives.com coaching directory.

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ACKNOWLEDGMENTS

I have met so many people throughout my life and poker career who have helped and guided me in some way that unfortunately, I won't be able to acknowledge them all.

First, I want to thank Alex Carr and his staking group Pocarr for giving me the opportunity to start playing online multi-table tournaments (MTTs). Pocarr started backing me when I couldn't beat $11 MTTs and assisted me all the way up to playing $10,000 buy-in world championship events. They believed in me, offered me staking and gave me access to world-class coaching when I was no one, and that is something I'll never forget.

When I was playing $22 MTTs I was very fortunate to get a private coaching session with Jon Van Fleet. In that first session we connected immediately. At the time I was working on my first "GTO ranges". Jon liked my ideas and invited me to listen in on his GTO study group, a group that included top tier players such as Stephen Chidwick and Elio Fox. At that time, they were studying Will Tipton's *Expert Heads-Up No-Limit Hold'em*, gathering weekly to go over the concepts in a time before GTO had gotten into the mainstream MTT realm and well before modern-day solvers existed. They made me part of the group despite the fact I was many levels below them, giving me the opportunity to thrive and realize my true potential and forever

changing the course of my poker career.

Later down the road other great poker minds such as Daniel Dvoress, Dylan Linde and Martin Kozlov joined our GTO study group. Martin was also obsessed with solving poker and our minds were very alike, so we worked together for a long time after the original GTO group dissolved. Martin introduced me to the rest of his poker crew and eventually I started traveling with them, playing the live poker circuit and meeting a lot of new and interesting people from all around the world. Today, Martin is one of my closest friends and I thank him for supporting me all this time.

PioSOLVER was the first GTO solver I ever used. I have received a lot of support from the program developers Piotr Lopusiewicz and Kuba Straszewski, who incorporated many of my ideas for general improvements into PioSOLVER. Working with them greatly helped me with my GTO study.

Thanks to Jonathan Little, Byron Jacobs and Dan Addelman for believing in me and offering me the opportunity to share my ideas with the world. They helped shape *Modern Poker Theory* into the book you are now reading. This book would not be possible without them.

And finally, thanks to my Mother, Hannia. Everything I have and everything I will ever be, I owe it to you!

Michael Acevedo, July 2019

FOREWORD

I first met Michael when he was a low- to mid-stakes grinder and I became his coach. From the start of our first session, I was struck by his level of enthusiasm and theoretical knowledge. When he showed me the Heads-Up Display (HUD) he had constructed in Hold'em Manager, I was impressed, and even a little envious. The HUD was about the most functional and deep-diving HUD I had ever seen and I have used quite a few paid-for HUDs. What really stood out was the incredible degree of attention to detail, and I was astounded by the amount of work it must have taken him.

That HUD, combined with Michael's background knowledge and eagerness, led me to invite him into a study group of which I was a member and which also included elite, high-stakes players such as Stephen Chidwick, Elio Fox and Martin Kozlov. There was a catch, though. Michael had to read four out of five chapters of Will Tipton's Expert Heads Up No Limit Hold'em in two days because we were reviewing the final chapter. This book is not exactly a page-turner and I had created the study group simply because I wanted some personal accountability around reading it and practicing. Frankly, I did not expect Michael to actually read it all but he showed up claiming he had, so I quizzed him and verified he'd done the reading and, still somewhat cautiously, let him into the group.

I must admit, another selfish reason I invited Michael to join the group is that I thought he might be happy to work on some of the Excel spreadsheets and other data-organizing tasks that we really didn't want to do. We were just beginning to learn PioSOLVER back then and Michael was a big help in structuring our findings and optimizing our studying. I would like to think that this was the moment when Michael began to discover his passion for studying theory, unearthing new ideas and doing the data-crunching necessary to get novel information.

However, the real reason why I made the offer to Michael is that I value hard work, persistence and enthusiasm above pretty much any other trait, even intelligence. As well as being very bright, Michael clearly has all three of these crucial traits.

I do not subscribe to the common high-stakes attitude of keeping knowledge hidden to keep the losing players losing. When I first started playing the cleverest players were, arguably, those who won the most as very little "modern" information (in the form of solvers, Nash and ICM calculations) existed at the time. Back then, players often formed social groups where they would exchange ideas and build on each other's insight. I was lucky enough to be in the right place at the right time and, from the beginning, surrounded myself with brilliant poker players. Now, with the existence of solvers, one can generally get objective answers to any question. Therefore, it is no longer the most intelligent or the most popular who make the most money, but rather those who are willing to put in the hours, grinding away and tinkering with these powerful but frustrating programs.

I know or know of pretty much everyone in the high stakes MTT community, with perhaps a few exceptions. I am certain that Michael has ran more sims and collected more data than any other individual I know. This book is a product of all that number-crunching combined with Michael's incredible aptitude for organizing and presenting data. Most, if not all, of the ranges that Michael includes in these books are GTO ranges that agree with my own GTO solutions. I must confess that I am almost never playing exact GTO, that I am constantly jumping between models and finding ways to widen and adapt based on my observations of my opponents. After all, poker is still a game of playing the player. However, I do use all these models as base points,

routinely switching or adapting models to fit the player frequencies that I'm up against. Using GTO ranges as a base strategy is pretty much the only way to study. Also, if you know what the unexploitable frequencies are, it is much easier to identify when others are playing in a way that is open to exploitation.

This book is very comprehensive and, with all of the mathematical equations, could even be intimidating to some. However, even if you skip the math, this book can be used as a reference guide for pre-flop raising and 3-bet ranges, push/fold charts and a glossary for nearly every poker term. As an advanced player, I found the flop chapters to be most instructive and I feel certain that there is no other book with this level of flop analysis. The use of equity buckets to visually describe equity distribution is a simple and effective way to find patterns without getting too lost in the minutiae.

For those reading the book, I offer a few pieces of general advice. First, if you are averse to math or think it isn't necessary to play good poker, you are both right and wrong. Sure, you can be a winning player without knowing the math behind a lot of the assumptions. However, if you truly want to master the game in a comprehensive way, I believe that math is necessary. Even if you hate math, you are indirectly doing math by trying to make winning plays. A strong foundation in math just means your EV estimations are more precise.

Second, all of this work off the table might seem silly since we do not actually do math or consult charts at the table that often. However, the more time off the table you put in, the more you begin to see patterns so that, finally, after some experimentation, playing and hard work, all of the knowledge becomes part of your unconscious and instinctive understanding.

Third, if you're reading this, you're probably putting off some of the more difficult sections of the book. Get back to work!

Jon Van Fleet (Apestyles), July 2019

INTRODUCTION

An Unspoken Truth

For years, top poker players have had access to private software that has helped them increase their edge even further but now the poker landscape is evolving. Software is becoming more and more sophisticated while also becoming more easily accessible to the general public. Today, anyone can get access to modern equity calculators, push/fold apps, range analysis software, EV decision trees and GTO solvers. When I first started playing online and learned about these tools, I assumed the top players were the ones who had mastered them and knew the math behind each and every possible situation. However, I couldn't have been more wrong. Even with the proliferation of these advanced tools, most poker players do not want to spend thousands of hours becoming proficient with each of them and they certainly do not want to set up dedicated servers to run week-long GTO calculations.

So, how do world-class players manage to get access to the most advanced poker theory without having to spend thousands of hours actually in the lab? They outsource the work! They get mathematicians and game theory experts to fulfill this task for them so they can spend their time doing what they enjoy the most; winning everyone's money at the tables.

I know this to be true because I am one of those specialists who has been creating cutting-edge content for them. Over the past few years I've been making theory videos and webinars for online staking groups, as well as private articles for my students. I have also sold in-depth GTO solutions to world-class players. I used to tell everyone that I was a professional poker player, but it was until the moment I wrote these very words that I realized that's not what I've actually been doing. My playing volume, both live and online, has been laughably low over the last few years. I suggest my students use a ratio of 80% play to 20% study, but my own ratio has probably been the exact opposite! Even so, I have good results and managed to rank as high as 117th worldwide on the PocketFives sliding leaderboard. I guess I can't really call myself a professional poker player if playing poker is the aspect of poker I spend the least amount of time doing. Having said that, I fully understand that playing is vitally important and I believe that if I wasn't playing at all I wouldn't be able to help my students the way I do. It is very important for the coach to stay up to date on the metagame and to know what his students are dealing with at the tables. I love the game of poker and, after finishing writing this book, all I want to do is hit the tables with everything I've got.

Modern Poker Theory is the culmination of years of research and coaching. I have put my heart into this book and did my best to make it different from all other theory books, most of which present heavy-duty theoretical work with little or no consideration for practical application. My goal is to make game theory accessible to everyone, so players won't have to spend all of their time running calculations and can instead do what they are supposed to be doing: playing poker!

What is the Game of Poker all About?

There are many reasons people play poker. Some play to have fun and socialize, others play for the thrill of running a big bluff or outthinking their opponents, and others play for the glory of winning a tournament, a bracelet, or making a living. Whatever their motivations are, no one plays poker to lose money and so, at their core, all poker players share the same goal (even if they do not realize it) which is to generate and maximize profit!

♦ What is profit?

♦ Profit = opponent mistakes - our mistakes

If you play in an environment where most players are simply terrible and play for a lot of money (such as in the golden age of online poker right after the Moneymaker Effect and before Black Friday) you can play quite poorly and still make a lot of money, as long as your opponents play worse than you. In fact, the opposite is also true. You could be the ninth best player in the world but if you made a point to only play against the eight players who are better than you, you will get destroyed.

In the current poker ecosystem, exploitative play will still make a lot of money but, as the average player becomes more skilled, the ratio of good players to bad players constantly increases. This leads to smaller edges because vigilant Villains are trying to exploit us at the same time as we are trying to exploit them and we no longer have the luxury of being able to ignore our own game. Many famous “top players” who failed to adapt and improve over the last few years have seen the game pass them by, forcing them to quit or move down because they can no longer beat the games.

Of the two components of the profit equation (our mistakes and our opponents’ mistakes) you have little to no control over how your opponents play, other than selecting good games to play. However, you can always work on minimizing your own mistakes.

So how do you generate and maximize profit?

♦ Fix leaks in your own game and find what others are doing wrong.

♦ Adjust to exploit them.

That's it. That is the GTO study premise. It is not only about balance and equilibrium. It is about understanding the game at its core and actively using that knowledge to generate value.

01

POKER FUNDAMENTALS

While this chapter involves a decent amount of math, I did my best to keep the number crunching and equations to a minimum. However, you must fully understand a few of the formulas because they will ensure you become proficient at many of the most important concepts in poker. Please do not be turned off by the math and understand that working through this chapter is well worth the effort.

Basic Concepts

This section covers the basic terms that are required to understand the advanced strategies explained throughout this book.

Table Positions

Early Position (EP)

At a 9-handed table *(Diagram 1)* there are three early positions. If there are fewer players seated at the table, these are the first positions to be removed.

- ♦ UTG (Under the gun) – The first player to act pre-flop.
- ♦ UTG1 – The second player to act pre-flop.

♦ UTG2 - The third player to act pre-flop.

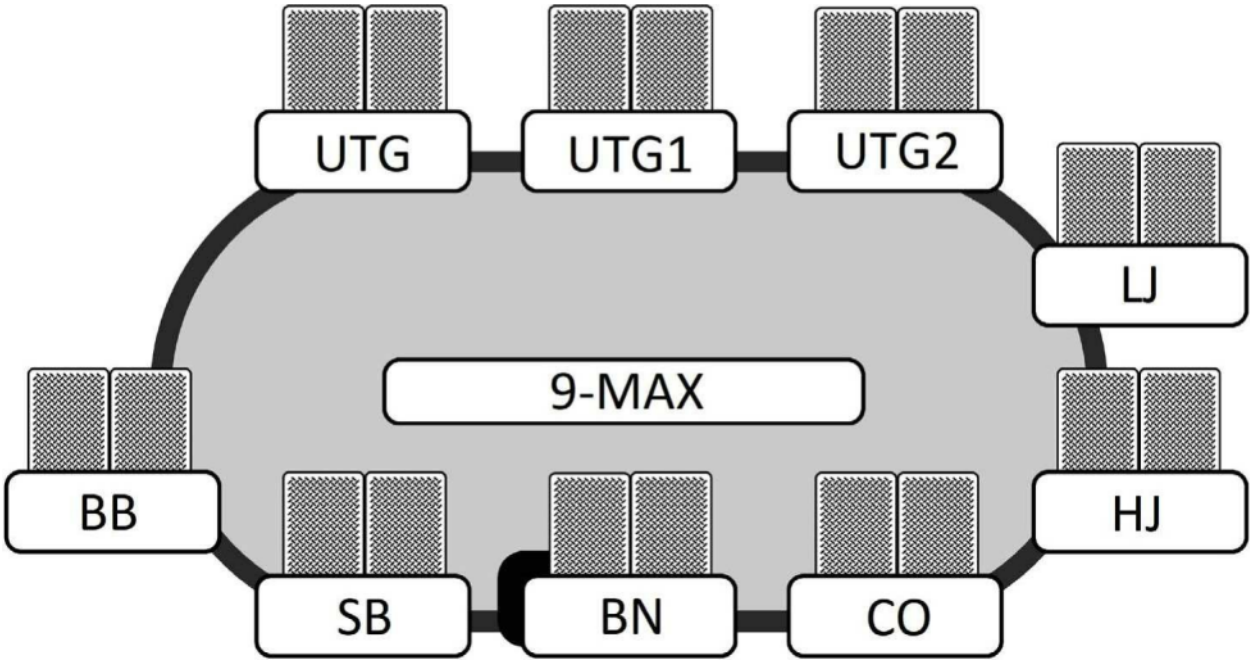


Diagram 1: Player Positions at the Table

Middle Position (MP)

♦ MP or Lojack (LJ) – The fourth player to act pre-flop.

♦ MP1 or Hijack (HJ) – The fifth player to act pre-flop.

Late Position (LP)

♦ Cutoff (CO) – The next-to-last player to act on all post-flop betting rounds.

♦ Button (BN) – The last player to act on all post-flop betting rounds.

Blinds

♦ Small Blind (SB) – The next-to-last player to act pre-flop. The first player to act post-flop.

♦ Big Blind (BB) – The last player to act pre-flop. The second player to act post-flop.

Poker Terms

Various terms are used throughout this book in order to discuss poker strategy concisely. While many of these terms may be familiar to you, some may be new. If you are ever unsure about the meaning of a sentence due to not understanding the terminology, please refer back to this section.

Active Players: The players involved in the hand, often referred to as the Hero and the Villain(s).
Hero: The player from whose perspective the hand is played.
Villains: Any of Hero's opponents involved in the hand.
Pre-flop: Any action that occurs before the flop is dealt.
Post-flop: Any action that occurs after the flop has been dealt.
In Position (IP): The player who acts last due to their relation to the dealer/button.
Out of Position (OOP): The player (or players) who do not act last due to their relation to the dealer/button.
Relative Position: A player has positional advantage over another player when he gets to act after him throughout the hand. For example, in the common situation of BB vs BN, BN gets to act last on each street for the rest of the hand, so BN is IP and conversely BB is OOP.
First In: Refers to the situation when the action gets to a player and no other player has previously voluntary entered the pot. For example, if Hero is on the BN and everyone folds around to him, he has the option to be the first in by either calling or raising.
Stack Size and Stack Depth: Stack depth is always displayed in terms of big blinds.
For example, if a player has 1,000,000 chips and the big blind is 100,000, he only has 10 big blinds (bb).
Effective Stack: The smallest stack size among the active players. In a heads-up pot the effective stack size determines the maximum amount either player can lose.
Bet-size: Bet-sizes are displayed either in big blinds (for example, Villain bets 2bb, 5bb, 25bb) or as a fraction of the pot (for example 1/3-pot, 1/2-pot, 2/3-pot).
The Nuts: A poker hand is considered "the nuts" if it is the strongest possible hand at a specific moment. For example, AA is the nuts pre-flop. J♣T♣ is the nuts on 9♥8♥7♦ but is no longer the nuts if the turn brings another heart, 9, 8, or 7 because stronger hands than a straight are then possible.
Effective Nuts: A poker hand that is not the actual nuts but is strong enough that it should be played as if it were the nuts. For example, 7♣7♥ is the effective nuts on 8♥7♦2♦.

Speculative Hand: A hand that is unlikely to be best at the moment but can improve to a powerful holding later.

Air: A hand with no showdown value or drawing potential that can only win the pot by bluffing.

Bluff Catcher: A hand that can only beat a bluff.

Pure Bluff: A bet or raise made with a hand that has little or no chance of improving on a later betting round with the intention of making a better hand fold on the current betting round.

Semi-Bluff: A bet or raise made with a hand that has a decent chance of improving on a later betting round with the intention of making a better hand fold on the current betting round.

Showdown Value: A poker hand has showdown value if, when compared to Villain's range, it can realistically win at showdown.

Nut Advantage or Nut Threshold: A player has the nut advantage if the effective nut hands make up a larger portion of his range than the Villain's range.

Passive Player: A player who tends to play his strong made hands and bluffs in a more passive manner than he should.

Aggressive Player: A player who tends to take the betting initiative when given the opportunity.

Regular: A player who regularly shows up in games and is assumed to play well and be experienced.

Pocket Pair: A starting hand with two cards of the same rank. For example, A♣A♦, J♠J♦, or 5♣5♥.

Draw: A player is drawing or on a draw if he has an incomplete hand and needs to improve with an additional card in order to have significant showdown value.

Gutshot or Inside Straight Draw: A draw with four outs to make a straight.

For example, 9-7 on Q-10-6.

Open-Ended Straight Draw (OESD): A draw that has eight outs to make a straight. For example, J9 on QT6.

Broadway: The nut straight, A-T.

K, Q, J, and T are referred to as broadway cards.

Any Two Cards (ATC): Refers to a range containing all possible holdings, often used for aggressive actions that can be taken regardless of a player's holding.

Coin Flip / Race: A situation where both players are all-in and both players have roughly a 50% chance to win the pot.

Cooler: A situation when two strong hands clash and there is no way for the player with the weaker hand to fold.

Versus (vs): Another word for "against". For example, Hero's AA vs Villain's J9.

Toy Game: A simplified game used to model specific aspects of a real game.

Game Abstraction: A game where there are restrictions placed on the players' strategies

intended to reduce the size and complexity of the game. The main types of abstractions are:

Information Abstraction: A situation where some of the information states are bundled together. For example, on the flop A♣K♣Q♣, the hands 3♥2♥, 3♠2♠ and 3♦2♦ can be considered as the same hand for strategic purposes.

Action Abstractions: A situation where some of the actions in the real game are assumed to not be usable. For example, removing a player's strategic option of calling or betting certain amounts, such as one big blind into a 100 big blind pot, or 100 big blinds into a 1 big blind pot.

Rake: Rake is the commission fee taken by a cardroom running a poker game. Some poker rooms charge a time-based rake, so each player has to pay a fixed amount per hour that they are sitting at the table, and other cardrooms charge rake as a percentage of the pot, usually 2.5% to 10% of the pot, depending on the game. There is usually a cap to the amount of money the casino takes from each pot. For example, in a poker game with 5% rake capped at $5, the maximum amount the house can take from the pot will be $5 from any pot that is $100 or larger. Most poker rooms also have the rule that rake is only taken if a flop is dealt, so any action that finishes without a flop being dealt will not be subject to rake. For example, if MP raises to 2.5bb, BN 3-bets to 8bb, MP 4-bets to 24bb and everyone else folds, the house won't take any money from the pot because the flop wasn't dealt, regardless of how much money went into the pot.

Calling Station: A player who never folds a made hand regardless of the action.

Player Actions

Call (c): Matching the current bet to continue in the hand.

Limp (l): Entering the pot by calling the minimum bet (1bb).

Raise (r): Increasing the price the other players have to call to enter the pot. Raising is also known as a 2-bet because the action of posting the big blind is considered as the first bet.

Check (x): The option to pass your turn. Pre-flop, it can only be done from the big blind if no one else raised. Post-flop, it can be done if you are first to act or if other players have checked to you.

Voluntary Put Money in the Pot (VPIP): When a player enters the pot by either calling or raising. Posting the blinds does not count as VPIP because the blinds are forced (not voluntary) bets.

Raise First In (RFI): When a player is first in and enters the pot by raising. Also referred to as open raising.

Two-bet (2-bet or 2b): The blinds are considered as the "First Bet", then the first person to raise the pot is making a "Second Bet" or "Two Bet"; RFI is a special case of 2bet when there are no limpers.

Steal: Raise First In from BN, CO or SB.
Isolate: Raising after someone has entered the pot with the intention of playing heads-up post-flop vs that player.
Minraise: When a player raises the minimum allowed, which is two times the last bet amount.
Minbet: Making the minimum bet allowed. Post-flop, this is one big blind.
Overbet: Making a bet that is larger than the size of the pot.
Three Bet (3-bet or 3b): Making a re-raise, which is to increase the bet after someone else raised.
Resteal: 3-betting after someone else steals.
All-in or Push: Betting all of your chips.
Open Shove or Open Jam: Going all-in when no one else has entered the pot before you.
3-bet-Jam, 3-bet-Shove, Reshove, or Rejam: Moving all-in after someone else has already raised.
Four-bet (4-bet or 4b), 5-bet and any subsequent number of bets: Refers to the number of bets that have been made during the current betting round.
Cold 4-bet: 4-betting when the player making the 4-bet was not the initial raiser. For example: UTG opens to 2bb, BN 3-bets to 5bb and the BB cold 4-bets to 12.5bb.
Cold Calling (cc): Calling a single raise when in position, or calling a 3-bet or 4-bet when you have not previously voluntarily put money in the pot. For example, MP opens to 2bb, CO 3-bets to 6bb, BN folds and SB cold calls.
Squeeze (sqz): 3-betting after someone raised and someone else called. For example, UTG1 opens to 2bb, CO cold calls, BN squeezes to 9bb.
Continuation Bet (C-bet): Post-flop bet made by the player who was the last aggressor in the previous betting round.
Donk Bet or Lead Out (DK): When the player who is OOP bets into the aggressor on the previous betting round, denying the option to C-bet.
Slow Play or Trap: To play a premium holding in a passive manner, hoping to induce a value-bet from an inferior hand or a bluff.

Action Lines

A “line” is a specific sequence of betting actions taken by a player.

Limp/Fold (l/f): A player enters the pot by limping (calling the big blind) and then folds to a raise.

Limp/Raise (l/r): A player enters the pot by limping and then re-raises after someone else raises.
Check/Fold (x/f): A player checks and then folds to an opponent's bet.
Check/Call (x/c): A player checks and then calls an opponent's bet.
Check/Raise (x/r): A player checks and then raises an opponent's bet.
Bet/Bet (b/b): Betting the turn after the opponent called or x/c the flop. Also known as double-barreling or two-barreling.
Bet/Bet/Bet (b/b/b): Betting the flop, turn, and river after the opponent called or x/c flop and turn. Also known as triple-barreling.

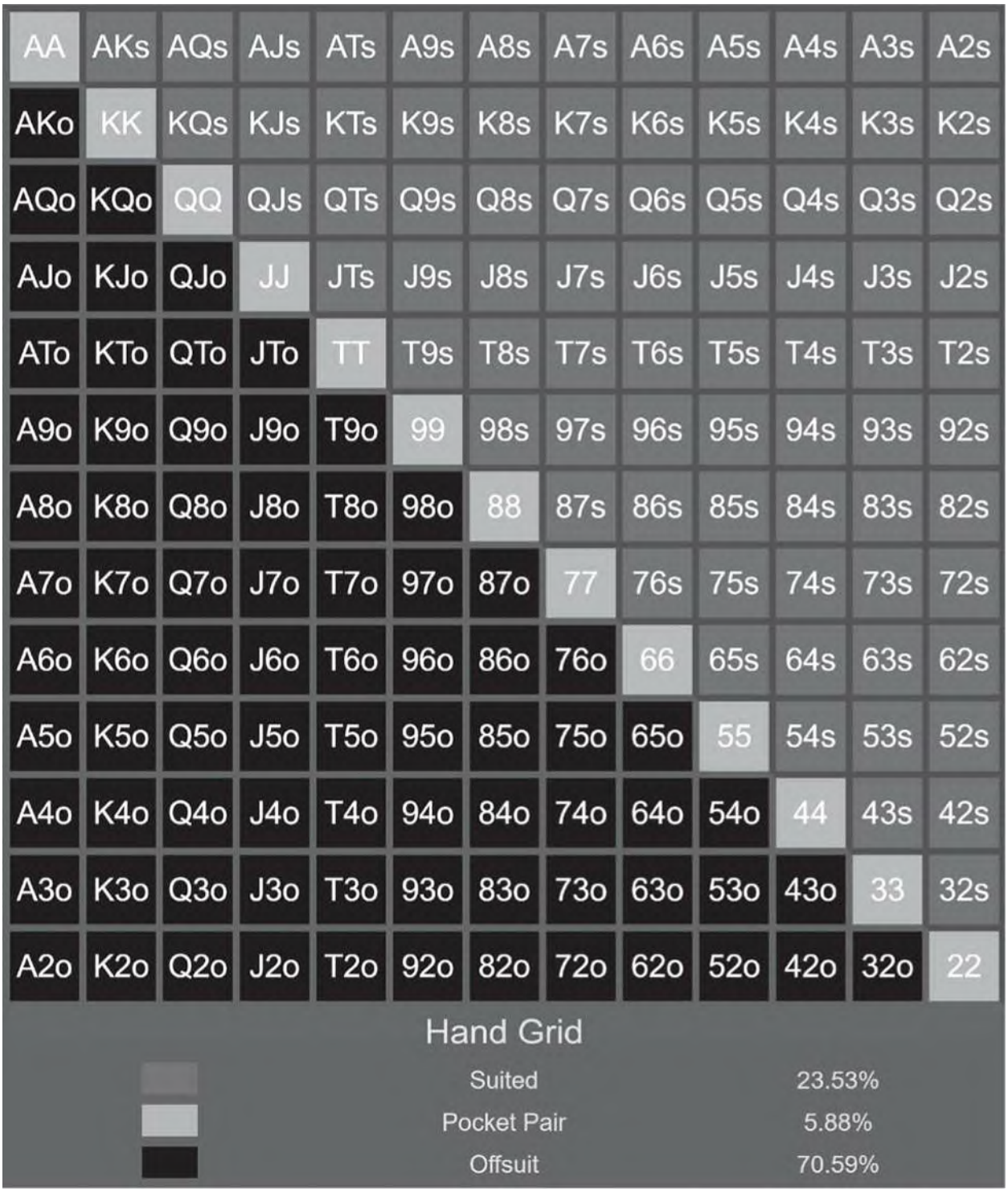
Hand Range

When players first start learning to play the game of poker, the first thing they simply must master is understanding hand values and, as a result, a beginner player only thinks about his own hand's strength. Later, as players become more advanced, they start thinking about their opponents' hands as well. Eventually, they get to the point where they don't try to put their opponents on a single hand, but instead assign them a range of possible holdings and work to narrow that range down based on each of their opponent's actions throughout the hand *(also known as hand reading)*. The best players take this even further and, while thinking about their opponents range, they also think about their own range and how it fares against their opponents range, in terms of equity, range polarization, balance, nut advantage and many other concepts that will be addressed throughout this book.

> *Poker may appear like a simple game to a novice, but the classic saying of "it takes a minute to learn, but a lifetime to master" certainly holds true.*

13×13 Hand Grid

The hand grid *(Hand Range 1)* is a graphical representation of a range. It contains all 169 possible pre-flop hands: 13 pocket pairs (5.88% of all hands) that are located diagonally from top left to top right, 78 suited hands (23.53% of all hands) located in the upper right half represented with an "s", and 78 offsuit hands (70.59% of all hands) located in the bottom left half represented with an "o".



Hand Range 1: The Basic Hand Grid

Example

Game: Live Cash Game

Effective Stack: $200
Players: 9
Blinds: $1/$2 (no ante)
Pre-flop: UTG raises to $10. We have observed this player for a while and our perception is that he is very tight, opting to only play premium starting hands. We have also noticed that he raises his stronger hands and calls with medium-strength hands.

Once a player decides to put money into the pot, they've revealed some amount of information about their range. We can use that information to assign the Villain a starting range of hands.

Start by asking which hands are consistent with Villain's actions, and then add those to the range one by one.

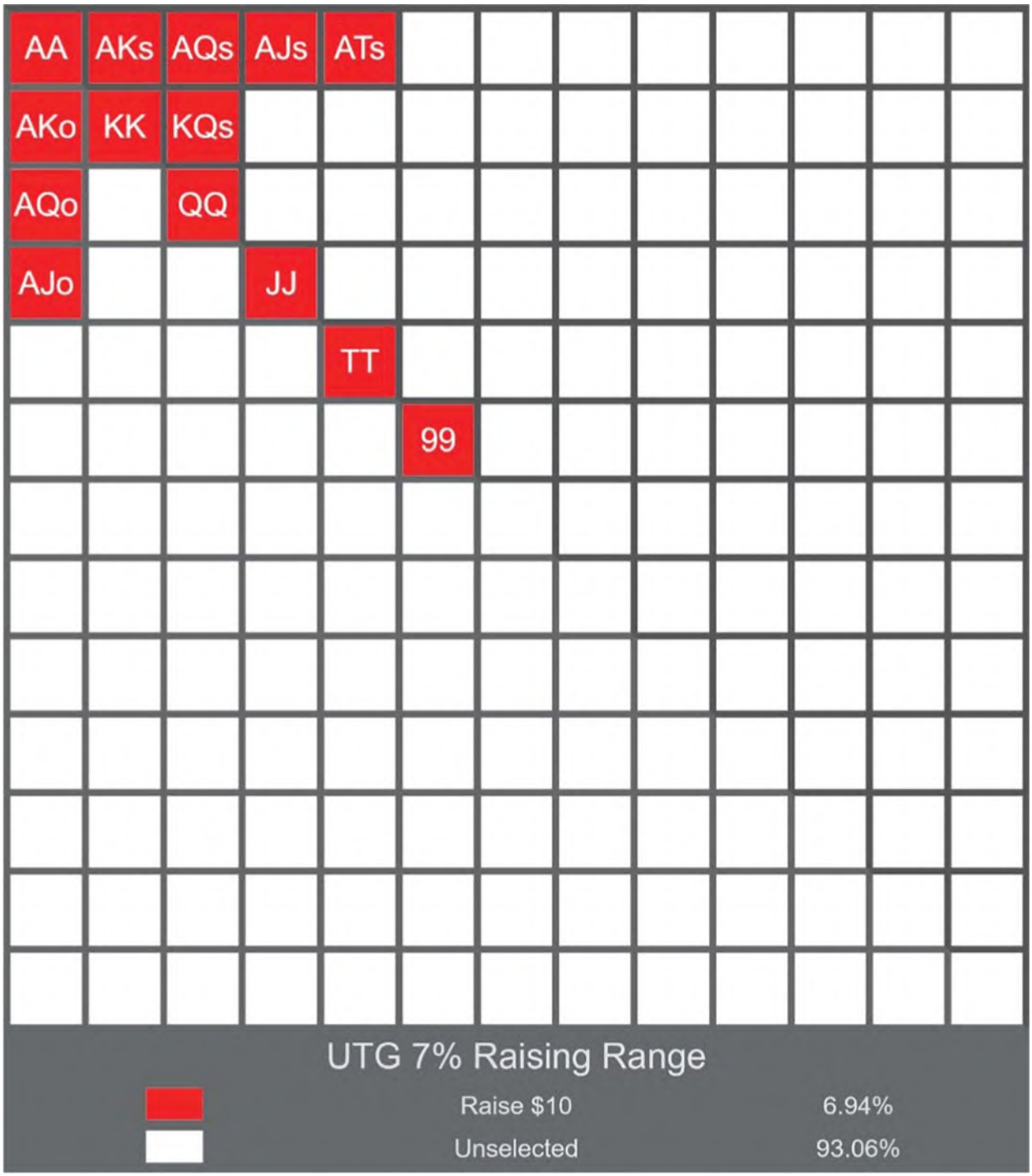
AA: It is definitely possible for Villain to hold AA at this point, and he would most definitely want to raise with it (unless he was known to slow play).
KK-99: All pocket pairs between KK and 99 are also likely to be in the Villain's raising range.
ATs+: AKs, AQs, AJs, and ATs are also likely to be in Villain's raising range.
AJo+, KQs: These are also hands that almost everyone raises from all positions.
In total, these hands make up 7% of all possible hands *(Hand Range 2)*.

Now consider the next tier of hands the Villain may play from this position, as well as his possible actions with them.

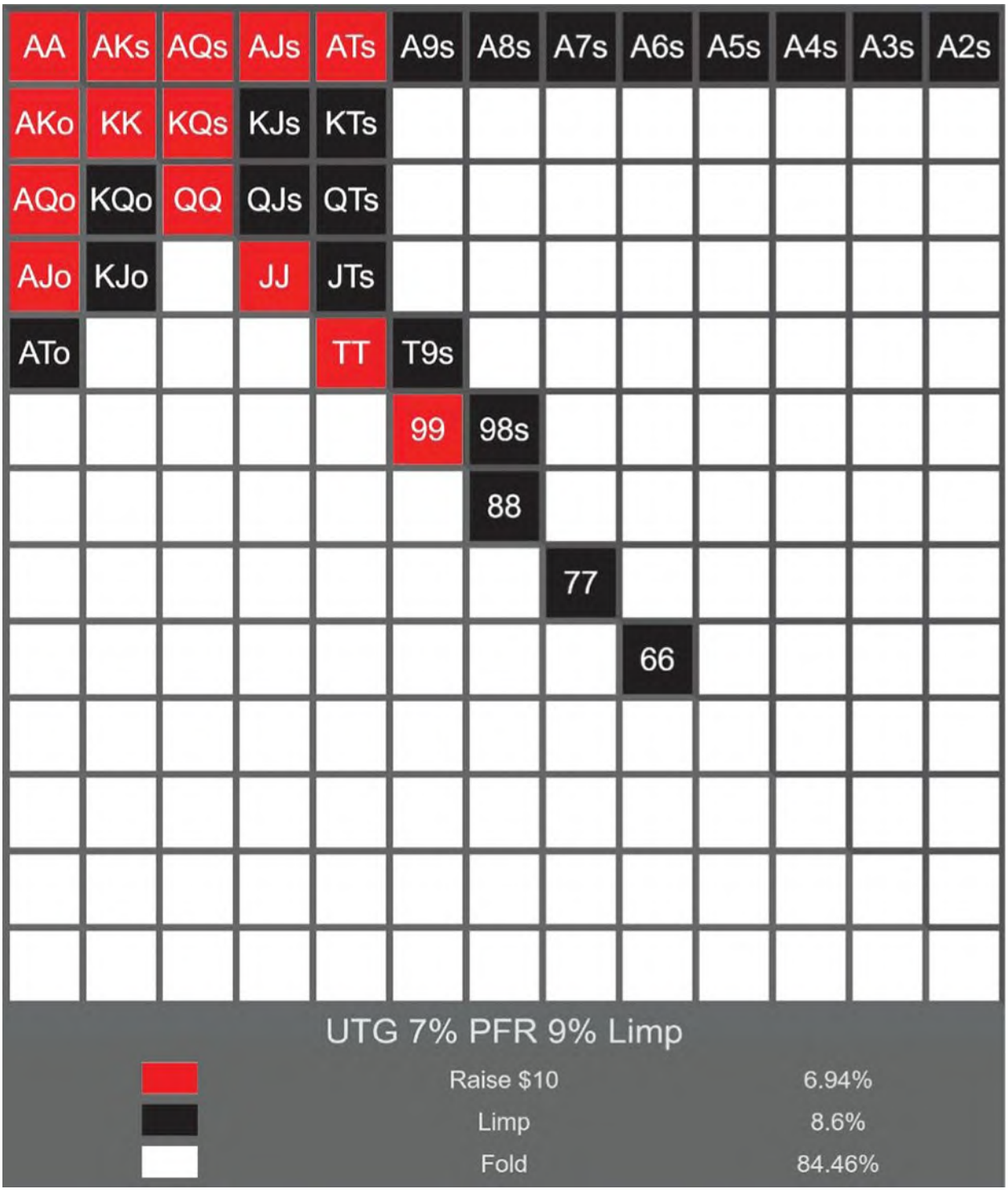
ATo, **A9s-A2s**, **KQo**, **KJo**, **88-66**, **KJs**, **KTs**, **QJs**, **QTs**, **JTs**, **T9s**, **98s** *(Hand Range 3)*, are all medium strength hands that this particular Villain may not consider good enough to raise but may be good enough to see a cheap flop. From past experience, you might know this opponent likes to limp these hands.

This strategy of raising with the premium hands and limping with medium-strength hands is not recommended because it is easy to exploit by simply raising when the Villain limps (because you know their hand can't be too strong) and by folding your medium-strength and weak hands when Villain raises (because you know they have a premium hand). Many Villains may not even be aware of what their range is in a particular situation but, by paying attention, you can notice their tendencies and adjust to take advantage of them.

By splitting his range in this way, Villain also makes his opponent's post-flop hand reading a lot easier. For example, if Villain never raises hands such as T9s or medium pocket pairs then, after they raise, their opponents will know on a flop like 8♣7♠6♦ that they can't have straights, sets or two pairs, and that their range will consist only of overpairs and overcards.

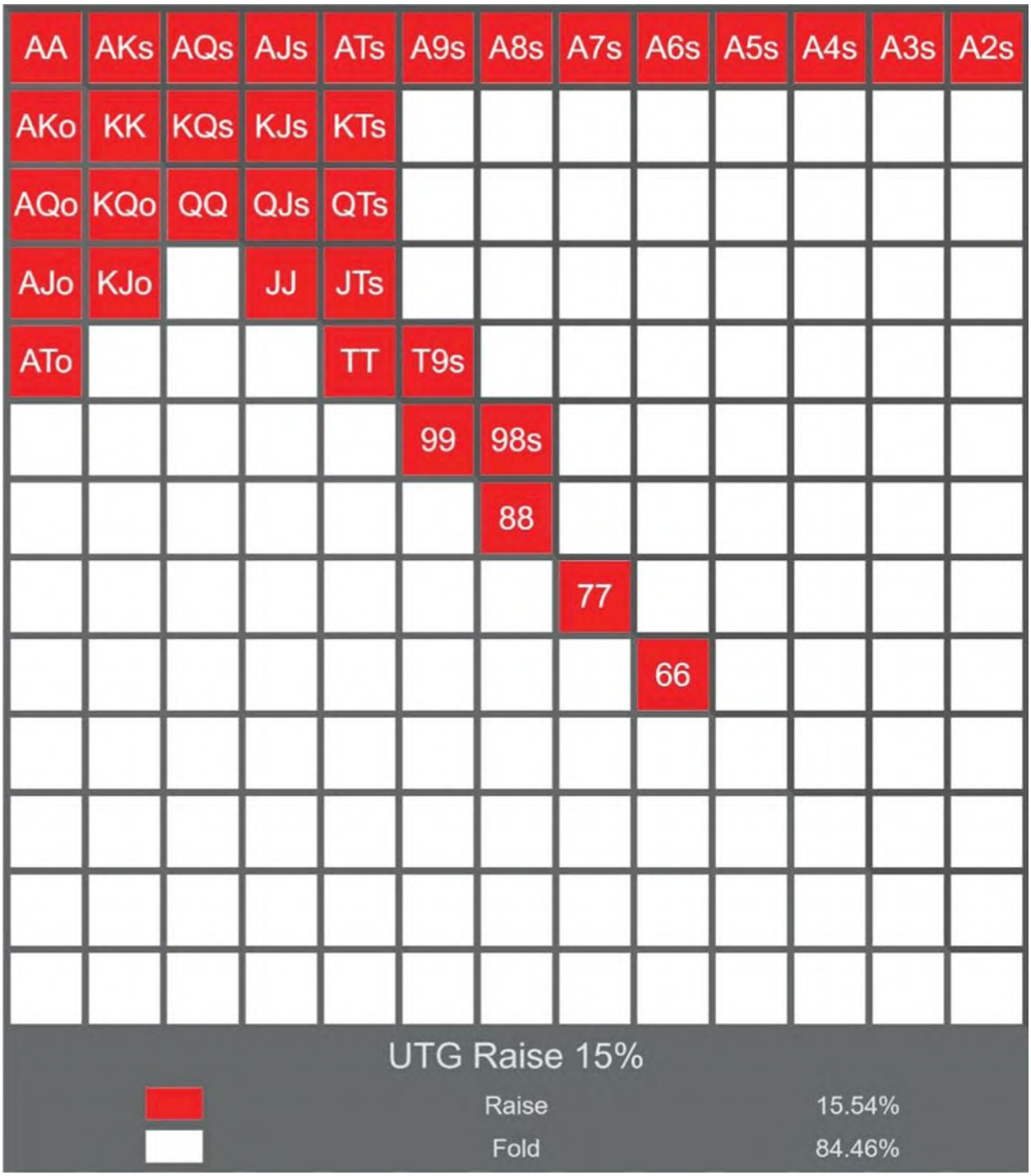


Hand Range 2: A Typical 7% Raising Range



Hand Range 3: A Typical Mixed Raising/Limping Range

The Villain would be much better-off playing a simpler strategy where they only enter the pot by raising with all hands they want to play, making them more difficult to read. This is a solid strategy that will work well from early position *(Hand Range 4).*



Hand Range 4: A Typical Early Position Raising Range

You must be careful about the information you give away after taking certain actions, because the more information your opponents have about your range, the better decisions they can make. Professional poker players come to the table with a well thought out plan. They have done the

work off the table and constructed their ranges in such a way that they are not easily exploitable. Of course, just memorizing a few range charts won't make anyone a world-class player but understanding the ranges in play will help you avoid common mistakes, allowing you to make better decisions.

Combinatorics

Combinatorics is the practice of breaking down ranges and counting individual combinations (combos) of hands in order to make better decisions. The formula to find the number of combinations of **k** objects you can choose from a set of **n** objects is as follows (note that in all of these examples the "!" represents the factorial function, meaning that you must multiply the number in question by all lower digits, e.g. 6! = 6 × 5 × 4 × 3 × 2 × 1 = 720):

$$Number\ Combinations = \frac{n!}{k!(n-k)!}$$

♦♦	♥♦	♠♦	♣♦
♦♥	♥♥	♠♥	♣♥
♦♠	♥♠	♠♠	♣♠
♦♣	♥♣	♠♣	♣♣

Diagram 2: Poker Suits 4x4 Grid

Pre-flop there are 169 distinct poker hands but, when we account for suits, the number of specific two-card poker hand combinations in a 52-card deck is:

$$Hand\ Combinations = \frac{52!}{2!(52-2)!}$$

$$Hand\ Combinations = \frac{52 * 51 * 50!}{(2 * 1)(50)!}$$

$$Hand\ Combinations = \frac{52 * 51}{2}$$

$$Hand\ Combinations = 1326$$

Pocket Pairs (PP)

The formula to calculate the number of combinations of PP in a player's range is:

$$Combination\ of\ PP = \frac{x * (x-1)}{2}$$

where X is the number of available cards remaining in the deck.

For any PP, this calculation is:

$$Combination\ of\ PP = \frac{4 * (4-1)}{2} = \frac{12}{2} = 6$$

The diagonal line in the 13×13 hand grid *(Hand Range 1)* represents PP. There are 13 different ranks of pairs and 6 different ways to make a PP of any rank, so there are 13 × 6 = 78 combinations of pocket pairs.

Unpaired Hands

The formula to calculate the number of combinations for unpaired hands is:

$$Combination\ of\ Unpaired\ Hands = (x * y)$$

where X and Y are the number of available cards remaining in the deck for each rank. Take AK for example. There are four aces in the deck and four kings in the deck, 4 × 4 = 16, so there are 16 combinations of AK (and any other unpaired hand) available.

Suited Hands

Suited hands are represented above the PP diagonal in the 13×13 hand grid. There are 78 total hands above the diagonal and four different suits for each, so there are 78 × 4 = 312 total combos of suited hands.

Offsuit Hands

Offsuit hands are represented below the PP diagonal in the 13×13 hand grid. There are 12 ways to make a non-paired offsuited hand, so there are 78 × 12 = 936 total combos of offsuit hands.

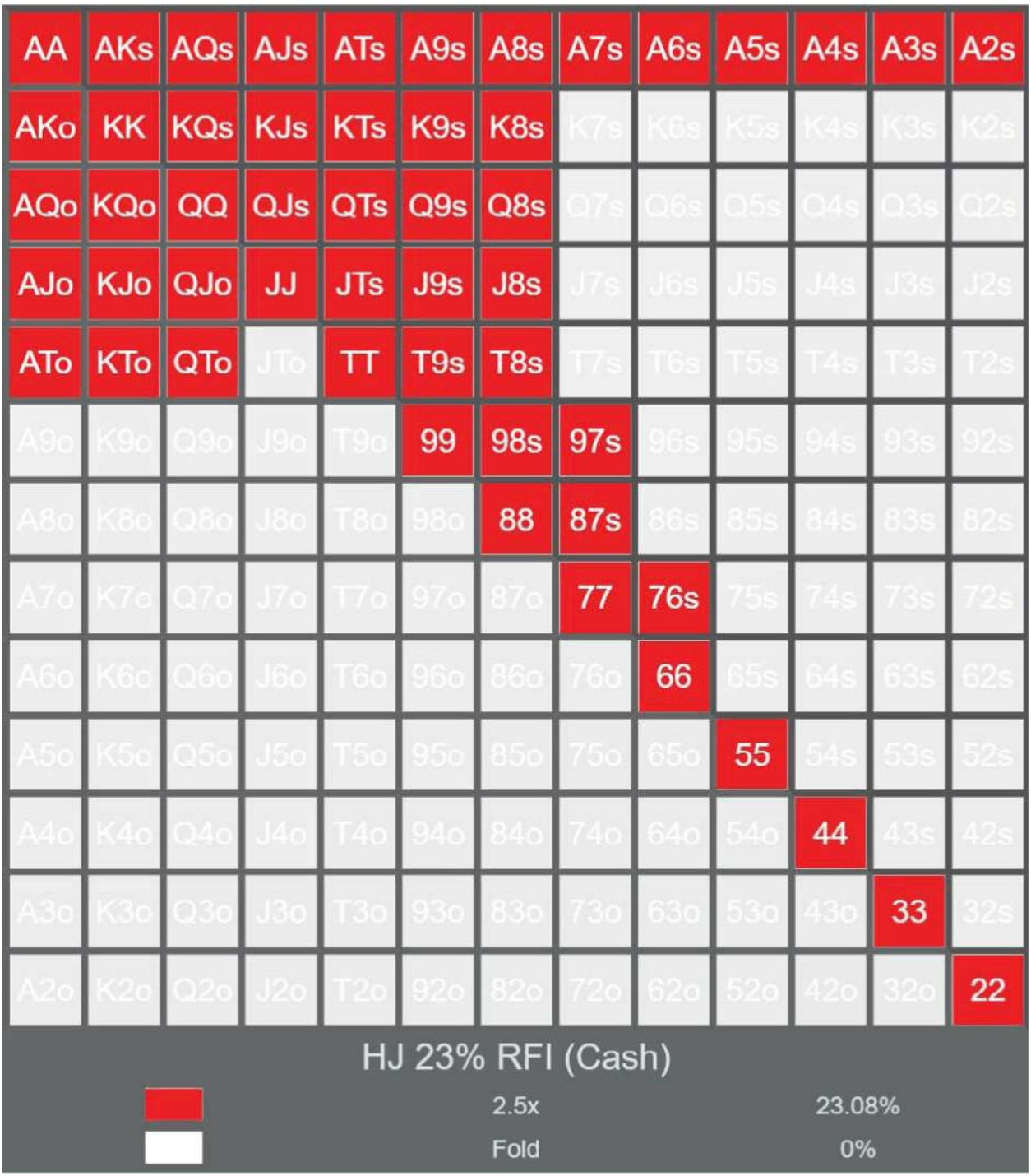
Therefore, in total there are 78 + 312 + 936 = 1,326 total different poker hand combos

Hand Ranges as Combinations

Thinking about hand ranges in terms of combos is much more difficult than “putting your opponent on a single hand” and requires a lot of practice to become proficient at it, but making this switch is something all players must do if they want to progress in their poker careers. All the best players in the world think about situations in terms of ranges and combos, not individual hands. This process will be difficult and tedious at first, but with practice it will become second nature.

Example
Game: Live Cash game
Stacks: Hero $1,200, Villain $760
Players: 9
Blinds: $5/$10 (no ante)
Pre-flop: Hero is in the BB with A♦3♦.
HJ is a regular. He raises to $25 and everyone folds to Hero, who calls.

Start by giving HJ a standard HJ opening range of 23% hands. You will rarely know Villain's exact range, so you have to estimate. *Hand Range 5* is a reasonable estimate.



Hand Range 5: A Reasonable Hijack Opening Range

Pre-flop Range Breakdown

Pocket Pairs: Villain's range contains all 13 ranks of pocket pairs, and there are 6 combos of each rank:

$$13 * 6 = 78\ pocket\ pair\ combos$$

Suited Hands: Villain's range contains 30 distinct suited hands, and there are 4 suits of each:

$$30 * 4 = 120\ suited\ hand\ combos$$

Offsuit Hands: Villain's range contains 9 distinct offsuit hands, and there are 12 of each:

$$9 * 12 = 108\ offsuit\ hand\ combos$$

Total Range

$$78 + 120 + 108 = 306\ combos$$

$$\frac{306}{1326} = 0.23 = 23\%\ of\ all\ possible\ hands$$

Post-flop Range Breakdown

Now we consider how Villain's range breaks down on a specific flop. We will consider the flop of A♣J♥9♥.

Made Hands

On this flop Villain has a total of 157 combos of made hands, as follows.

Sets (7 Combos)

AA: The A♣ is on the flop, and we block the A♦ (meaning it is in our hand), so the only combo left is A♠A♥.

JJ/99: Using the pocket pairs formula for JJ:

$$\text{Combinations of JJ} = \frac{x * (x-1)}{2}$$

The J♥ is on the flop, so there are only three possible jacks left in Villain's range: J♠, J♥ and J♣.

$$\text{Combinations of JJ} = \frac{3 * (3-1)}{2} = 3$$

The process is exactly the same for 99, so we have a total of:
1 combination of AA, 3 combinations of JJ, and 3 combinations of 99.

Two Pair (10 Combos)

AJ: The A♣ and the J♥ are on the flop, we block the A♦, so there are 2 aces and 3 jacks remaining.

$$\text{Combinations of AJ} = (2 * 3) = 6$$

A9: Villain's range doesn't have any offsuit A-9. The A♣ and the 9♥ are on the flop, so A♣9♣ and A♥9♥ are not possible. We block the A♦, so Villain can't have A♦9♦, which makes A♠9♠ the only A-9 combo left in Villain's range.
J9: Villain's range doesn't have any offsuit J9. The J♥ and the 9♥ are on the flop, so there are 3 combos of J9s in Villain's range.

Top Pair (38 Combos)

AK: There are 2 aces and 4 kings left:

$$\text{Combinations of AK} = (2 * 4) = 8$$

Do the same process for AQ and AT for a total of total 24 combos.
A8s-A2s: The A♣ is in the flop, and we block the A♦ so there are only 2 suits left for each one of the 7 different ranks of suited aces: 7 * 2 = 14 combos

Middle Pair (30 Combos)

KJ, QJ: 24 combos (repeat the same process used for top pairs).
JTs, J8s: 6 combos.

Bottom Pair (15 Combos)
K9s, Q9s, T9s, 98s, 97s

Pocket Pair 1/2 (12 Combos)
KK, QQ: Pocket pair 1/2 means pocket pairs between top and middle flop card.

Pocket Pair 2/3 (6 Combos)
TT: Pocket pair 2/3 means pocket pairs between middle and bottom flop card.

Underpair (39 Combos)
33: We have the 3♦ in our hand so there are only 3 combos left of 33. The other pairs (36 combos) are 88, 77, 66, 55, 44, 22.

Draws
Villain has 72 drawing hands, made up as follows.

Flush Draw: (8 combos)
Straight Flush Draw: 6 combos: K♥Q♥, K♥T♥, Q♥T♥, Q♥8♥, T♥8♥, 8♥7♥
Nut Flush Draw: 0 combos: the nut flush draw is also top pair and it has already been accounted for when counting the top pairs: A♥K♥, A♥Q♥, A♥T♥, A♥8♥, A♥7♥, A♥6♥, A♥5♥, A♥4♥, A♥3♥, A♥2♥.
Second Nut Flush Draw: 1 combo: K♥8♥
Other Flush Draws: 1 combo: 7♥6♥

8-Out Straight Draw (18 Combos)
QT: There are 16 combos of QT, but we already accounted for Q♥T♥, so there are only 15 combos left.
T8s: We already accounted for T♥8♥, so there are only 3 combos left.

4-Out Straight Draw (36 Combos)

KQ, KT: There are 16 combinations of each, but we already accounted for K♥Q♥ and K♥T♥, for a total of 30 combinations.
Q8s, 87s: We already accounted for Q♥8♥ and 8♥7♥, so there are only 3 suits left of each hand, for a total of 6 combos.

Air (6 Combos)
Accounting for card removal on the flop (because A♦, 3♦, A♣, J♥ and 9♥ are not available), Villain's range goes from 306 combos to 225 combos, and 219 combos are either a made hand or a draw, so only 6 combos in Villain range are pure air, these being K♣8♣, K♦8♦, K♠8♠, 7♣6♣, 7♦6♦, 7♠6♠

Full Range Stats
Instead of going through this tedious process by hand each and every time we want to break down a poker situation, we can use range analysis software such as flopzilla.com or an equity calculator such as power-equilab.com to get the flop stats effortlessly just by entering the ranges in play. In this case the range breaks down as follows. Note that the percentages will add up to more than 100% as some hands fall into two categories.

Set: 3.11%
Two Pair: 4.44%
Top Pair: 16.9%
Mid Pairs: 18.63%
Weak Pair: 26.7%
Flush Draw: 8%
OESD: 8.89%
Gutshot: 17.8%
Air: 2.67%

Key Metrics

Pot Odds and Outs

Pot odds represents the ratio between what you stand to gain in a poker hand and what you have to risk in order to get it. Pot odds are important because, when compared to the probability of

winning the hand, they can help players estimate the profitability of making a call.

Simply put, pot odds are a reward-to-risk ratio. For example, consider a hypothetical poker situation where you know Villain holds A♠K♠ on A♣8♥7♥ and you hold Q♥J♥. The pot is $100, and Villain goes all-in for another $100.

You need to decide which line is best, calling or folding. So, how do you know if calling with your draw is a profitable play?

First, you need to figure out your pot odds.

$$Pot\ Odds = \ Reward{:}Risk$$

You need to risk $100 to win $200 (Villain bet + starting pot) so pot odds are:

$$Pot\ odds = \ 200:100\ or\ 2{:}1$$

Pot odds can also be calculated as a percentage using the formula:

$$Pot\ Odds = \frac{Risk}{Risk + Reward}$$

So, in this case:

$$Pot\ Odds = \frac{100}{100 + 200} = \frac{100}{300} = \frac{1}{3}$$

$$Pot\ Odds = \ 0.33 = 33\%$$

This means you need to win at least 33.3% of the time to justify calling, assuming no abnormal tournament payout or bankroll implications.

Now to calculate your probability of winning the hand, let's introduce the concept of outs.

Outs

An out is any unseen card that if dealt will improve your hand. In the case of Q♥J♥, any heart will improve us to the best hand because we know Villain has AK with no hearts (unless both

exactly the A♥ K♥ come on the turn and river).

There are 13 hearts in the deck, and since we hold the Q♥J♥ and the 8♥7♥ are on the flop, the remaining hearts in the deck are: A♥, K♥, T♥, 9♥, 6♥, 5♥, 4♥, 3♥, 2♥ for a total of 9 outs. Now we can use the following formulas to calculate the probability of making our hand based on the number of outs:

$$Probability\ (Flop \rightarrow Turn) = \frac{47 - Outs}{Outs}$$

$$Probability\ (Turn \rightarrow River) = \frac{46 - Outs}{Outs}$$

$$Probability\ (Flop \rightarrow River) = \frac{1}{1 - \left(\frac{47 - outs}{47} * \frac{46 - Outs}{46}\right)} - 1$$

In the following sections, I will explain each formula in detail, although in this case we are only interested in the third formula because our opponent is all-in, meaning if we call his bet, we get to see both the turn and river.

Probability of Catching a Heart on the Turn

A deck of cards contains 52 cards. We know 5 of them, our 2 hole cards and the 3 cards on the flop. That leaves 47 unknown cards, 9 of which will give us the best hand and 38 will not, so the ratio of non-flush cards to flush cards is: 38:9 or 4.2:1.

$$Probability\ (Flop \rightarrow Turn) = \frac{47 - Outs}{Outs}$$

$$Probability\ (Flop \rightarrow Turn) = \frac{47 - 9}{9}$$

$$Probability\ (Flop \rightarrow Turn) = \frac{38}{9} = \frac{4.2}{1}$$

To convert 4.2:1 to a percentage, simply add the two numbers in the ratio (4.2 and 1) together and divide 100 by that number:

$$\frac{100}{4.2 + 1} = \frac{100}{5.2} = 19\%$$

Probability of Catching a Heart on the River (if Already on the Turn)

A deck of cards contains 52 cards, and we know 6 of them, our 2 hole cards and the 4 cards on the flop and turn. That leaves 46 unknown cards, 9 of which will give us the best hand and 37 that will not, so the ratio of non-flush cards to flush cards is: 37:9 or 4.1:1.

$$Probability\ (Turn \rightarrow River) = \frac{46 - Outs}{Outs}$$

$$Probability\ (Turn \rightarrow River) = \frac{46 - 9}{9}$$

$$Probability\ (Turn \rightarrow River) = \frac{4.1}{1}$$

Using the same method as before to convert the ratio to a percentage we get:

$$\frac{100}{4.1+1} = \frac{100}{5.1} = 19.6\%$$

Probability of Catching at Least One Heart on the Turn or River

$$Probability\ (Flop \rightarrow River) = \frac{1}{1 - \frac{47 - outs}{47} * \frac{46 - Outs}{46}} - 1$$

$$Probability\ (Flop \rightarrow River) = \frac{1}{1 - \left(\frac{38}{47} * \frac{37}{46}\right)} - 1$$

$$Probability\ (Flop \rightarrow River) = \frac{1.86}{1}$$

Finally, converting these to a percentage gives:

$$\frac{100}{1.86+1} = \frac{100}{2.86} = 35\%$$

Now all we have to do is compare the pot odds to the odds of making our hand. Remember, the Villain pushed all-in for $100 into a $100 pot *(Table 1)*.

	Pot Odds	Odds of Making a Flush by the River
Odds Against	2:1	1.86:1
Percentage	33%	35%

Table 1

When using the x:y ratio form (odds against making your hand) the hand odds have to be lower than the pot odds for the call to be profitable. In this case 2 > 1.86.

When using the percentage form, the hand odds have to be greater than the pot odds for the call to be profitable, in this case 35% > 33%.

A good way to think about this is, "I know I will win 35% of the time and I only need to win 33% of the time. Since 35% is larger than 33%, I have a profitable call."

Here you are getting the right odds, so calling with the flush draw is profitable.

An easy way mentally to approximate the odds percentage using outs is as follows:

$$\boldsymbol{Odds}:(\boldsymbol{Flop}\rightarrow\boldsymbol{Turn}) = (Outs * 2) + (1\%)\ if\ more\ than\ 5\ Outs\ \ or\ \ + (2\%)\ if\ more\ than\ 13\ Outs$$

$$\boldsymbol{Odds}:(\boldsymbol{Turn}\rightarrow\boldsymbol{River}) = (Outs * 2) + (1\%)\ if\ more\ than\ 5\ Outs\ or\ \ + (2\%)\ if\ more\ than\ 13\ Outs$$

$$\boldsymbol{Odds}:(\boldsymbol{Flop}\rightarrow\boldsymbol{River}) = (Outs * 4) - (Outs - 8)\ \ if\ more\ than\ 9\ outs$$

In our example this works as follows.

$$\boldsymbol{Odds}:(\boldsymbol{Flop}\rightarrow\boldsymbol{River}) = (9 * 4) - (9 - 8) = 36\% - 1\% = 35\%$$

The following table *(Table 2)* gives the odds for varying numbers of outs.

Outs	Flop -> Turn Odds	Turn -> River Odds	Flop -> River Odds
1 Out	45.9-to-1 (2.13%)	45.1-to-1 (2.17%)	22.3-to-1 (4.26%)
2 Outs	22.5-to-1 (4.26%)	22.0-to-1 (4.35%)	10.9-to-1 (8.42%)
3 Outs	14.7-to-1 (6.38%)	14.3-to-1 (6.52%)	7.0-to-1 (12.49%)
4 Outs	10.8-to-1 (8.51%)	10.5-to-1 (8.70%)	5.1-to-1 (16.47%)
5 Outs	8.4-to-1 (10.64%)	8.2-to-1 (10.87%)	3.9-to-1 (20.35%)
6 Outs	6.8-to-1 (12.77%)	6.7-to-1 (13.04%)	3.2-to-1 (24.14%)
7 Outs	5.7-to-1 (14.89%)	5.6-to-1 (15.22%)	2.6-to-1 (27.84%)
8 Outs	4.9-to-1 (17.02%)	4.8-to-1 (17.39%)	2.2-to-1 (31.45%)
9 Outs	4.2-to-1 (19.15%)	4.1-to-1 (19.57%)	1.9-to-1 (34.97%)
10 Outs	3.7-to-1 (21.28%)	3.6-to-1 (21.74%)	1.6-to-1 (38.39%)
11 Outs	3.3-to-1 (23.40%)	3.2-to-1 (23.91%)	1.4-to-1 (41.72%)
12 Outs	2.9-to-1 (25.53%)	2.8-to-1 (26.09%)	1.2-to-1 (44.96%)
13 Outs	2.6-to-1 (27.66%)	2.5-to-1 (28.26%)	1.1-to-1 (48.10%)
14 Outs	2.4-to-1 (29.79%)	2.3-to-1 (30.43%)	0.95-to-1 (51.16%)
15 Outs	2.1-to-1 (31.91%)	2.1-to-1 (32.61%)	0.85-to-1 (54.12%)
16 Outs	1.9-to-1 (34.04%)	1.9-to-1 (34.78%)	0.75-to-1 (56.98%)
17 Outs	1.8-to-1 (36.17%)	1.7-to-1 (36.96%)	0.67-to-1 (59.76%)
18 Outs	1.6-to-1 (38.30%)	1.6-to-1 (39.13%)	0.60-to-1 (62.44%)
19 Outs	1.5-to-1 (40.43%)	1.4-to-1 (41.30%)	0.54-to-1 (65.03%)
20 Outs	1.3-to-1 (42.55%)	1.3-to-1 (43.48%)	0.48-to-1 (67.53%)
21 Outs	1.2-to-1 (44.68%)	1.2-to-1 (45.65%)	0.43-to-1 (69.94%)
22 Outs	1.1-to-1 (46.81%)	1.1-to-1 (47.83%)	0.38-to-1 (72.25%)

Table 2: Outs to Odds Chart

The following table *(Table 3)* identifies the number of outs generated by typical hold'em scenarios.

Situation	Outs
Set Over Set	1
Under Pair to Hit a Set	2
Dominated Pair to Make Two Pair	3
Gut-shot Straight Draw / Two Pair to Make a Full House	4
One Pair to Make Two Pair or Trips	5
Two Overcards to Make a Pair	6
Set to Make a Full House or Quads	7 on the flop, 10 on the turn
Open-ended Straight Draw	8
Flush Draw	9
Gut-shot + Two Overcards	10
Flush Draw + Gut-shot	12
Open-Ended Straight Draw + Two Overcards	14
Flush Draw + Open-Ender / Flush Draw + Two Overcards	15
Open-Ender + Flush Draw + Two Overcards	21

Table 3: Common NLH Scenarios

Backdoor Draw/Runner-Runner Draw

A backdoor draw is a drawing hand that needs to catch two outs to improve to the best hand. The probability of completing a backdoor flush draw (BDFD) is given by:

$$Backdoor\ Flush\ Draw\ \% = \frac{Outs}{Unseen\ cards} * \frac{(Outs - 1)}{(Unseen\ cards - 1)}$$

$$Backdoor\ Flush\ Draw\ \% = \frac{10}{47} * \frac{(10 - 1)}{(47 - 1)} = 4.16\%$$

The probability of completing a backdoor straight draw (BDSTD) with a three-card rundown such as JT9 is equal to the probability of catching a Q or an 8 on the turn that will generate eight more outs to complete, plus the probability of catching a K or a 7 on the turn that will generate four more outs to complete.

$$Backdoor\ Open\ Ended\ Straight\ Draw\ \% = \frac{8}{47} * \frac{8}{46} = 2.96\%$$

$$Backdoor\ Gutshot\ Straight\ Draw\ \% = \frac{8}{47} * \frac{4}{46} = 1.48\%$$

$$Backdoor\ Straight\ Draw\ \% = 2.96\% + 1.48\% \ = 4.44\%$$

Note that the probability of completing a one-out draw on the turn or river is 4.26%. This is almost the same as the probability of completing either of these backdoor draws, so having a BDFD or BDSTD on the flop is roughly as valuable as having one extra out.

Further Important Drawing Concepts

The following concepts are also important to keep in mind when considering drawing situations.

- **Dead Outs:** Dead outs improve your hand to the made hand you are drawing to while at the same time improving Villain's hand to a hand that beats you. For example, having an open-ended straight draw generally means that you have eight outs to improve to the best hand. However, if the Villain holds a flush draw, two of your outs will also make the Villain a flush. So, in reality, you only have six live outs.
- **Drawing Dead:** A player is drawing dead when all the outs are dead. So even if Hero's hand improves, he will still lose to a player who either already has a better hand or will improve to a better hand.
- **Implied Odds:** This refers to how much you may expect to win on future betting rounds when you complete your draw.
- **Reverse Implied Odds:** This refers to how much you may lose on future betting rounds in the event that you complete your draw but lose to a better hand.
- **Pot Committed:** You are pot committed when the pot odds generated by your remaining stack are greater than the odds of winning the hand. Thus folding to any bet or raise would be an incorrect play.

Equity (Eq)

Equity is your share of the pot as determined by your current chance of winning or splitting at a point in the hand. It is how often you would win the pot on average if there were no further betting and all cards were played out. Equity can be easily obtained using an equity calculator.

Here are two that you can access for free: pokerstrategy.com/poker-software-tools/equilab-holdem or propokertools.com/simulations.

There are various different ways to consider equity as we will now see.

Hand vs Hand Equity

Poker hands cannot be ranked according to strength because each hand's strength is relative to the opponent's hand or range of hands.

Let's examine the following three hands using equity and try to decide which one of them is the strongest: AKo, JTs, or 22 *(Table 4)*.

Hand vs Hand Equity	AKo	JTs	22
AKo	50%	59.49%	47.35%
JTs	40.51	50%	53.84%
22	52.65	46.16%	50%

Table 4: Hand vs Hand Equity Calculations

As we can see, AKo has more equity than JTs, and 22 has more equity than AKo. You would think that, through logical deduction, 22 must also have more equity than JTs. However, it turns out that JTs actually has more equity than 22. Therefore there is no way to independently rank these three hands.

Even if hand vs hand equity can't be used to rank poker hands in a vacuum, it can help us develop an understanding of the way poker hands match up against each other *(Table 5)*.

Matchup	Example	Equity
Over Pair vs Two Undercards	AA vs KQ	86%
Pair Domination	AA vs KK	82%
One Card Domination	AK vs AQ	74%
Pair vs One Overcard	KK vs AQ	71%
Two High Cards vs Two Undercards	AK vs 98	64%
One Overcard vs Two Middle Cards	AT vs KJ	60%
Underpair vs Two High Cards	99 vs AQ	55%
Two High Cards vs Underpair	AJ vs TT	44%
Two Live Cards vs Two Overcards	87 vs AK	38%
Trash Cards vs High Cards	72 vs QJ	32%
One Overcard vs Pocket Pair	AT vs KK	30%
One Dominated Card	A9 vs AQ	27%

Table 5: Common Preflop Equity Matchups

Hand vs Range Equity

When playing poker, you will never know for sure what your opponents two hole cards are. However, you can assign a range of hands based on their actions, and then calculate your equity against that range.

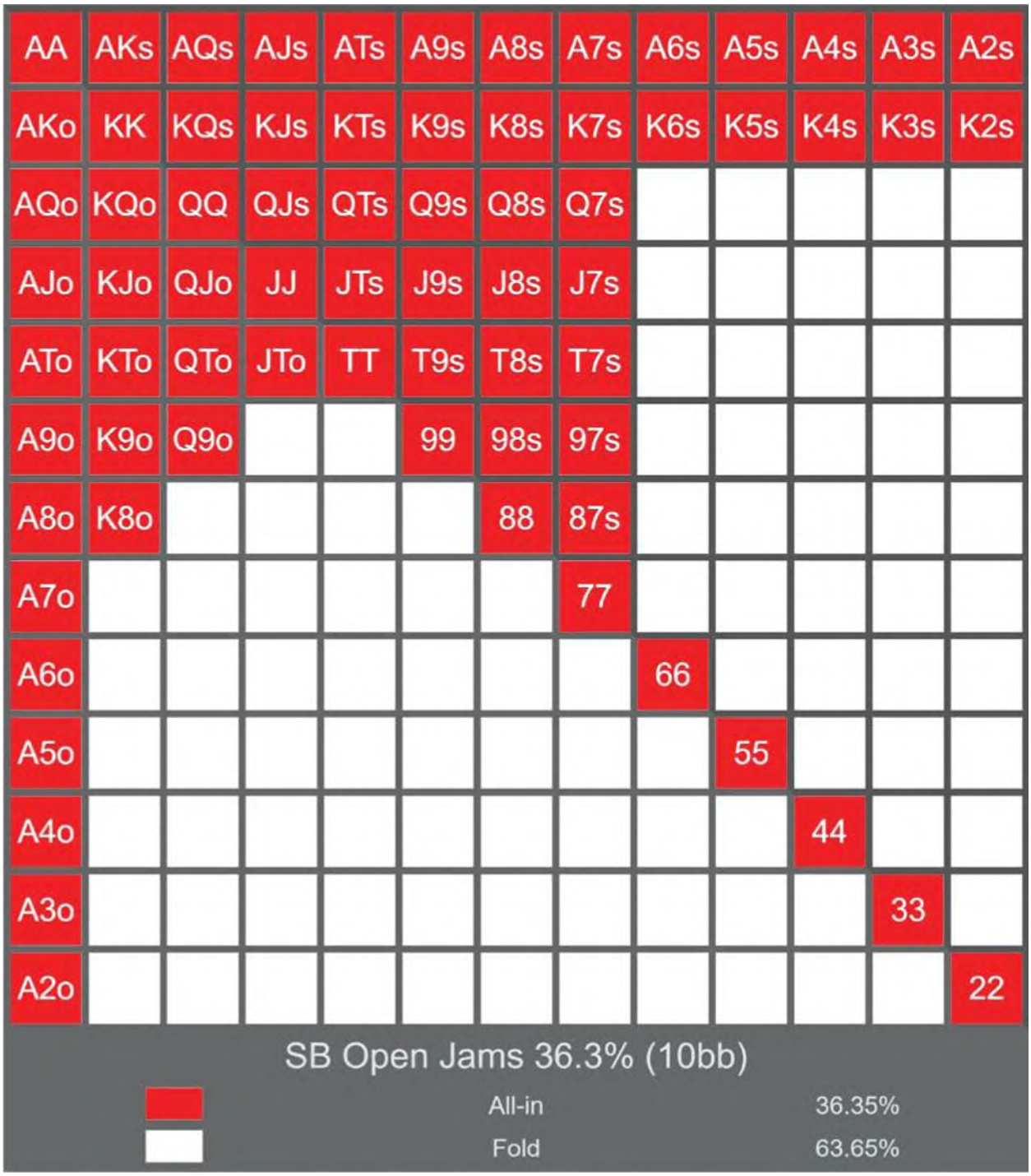
Example
Game: $100 3-max online Sit & Go
Stacks: BN 30bb, SB 10bb, BB 20bb
Players: 3 (no ante)
Pre-flop: (1.5bb) BN folds. SB is a tight player who goes all-in for 10bb. You are in the BB with Q♣T♠ and have to decide whether to call or fold.

Using the pot odds formula gives:

$$Pot\ Odds = \frac{Risk}{Risk + Reward}$$

$$Pot\ Odds = \frac{9}{9 + 11} = 0.45 = 45\%$$

The call will be profitable if your hand can win at least 45% of the time (i.e. has 45% equity). Since you know Villain is a tight player, you can assign him a tighter range than you would assign a standard or loose player *(Hand Range 6)*.



Hand Range 6: SB Opening Jamming Range (10bb)

Hand	Equity vs Villain Range	Equity Difference Compared to 45%	Action
76s	36.05%	-8.95%	Fold
A2o	44.69%	-0.31%	Fold
KTo	47.30%	2.30%	Call
QTo	42.97%	-2.03%	Fold
JJ	68.80%	23.80%	Call
22	45.94%	0.94%	Call

Table 6: Various Hand Equities and Equity Differences Compared to 45%

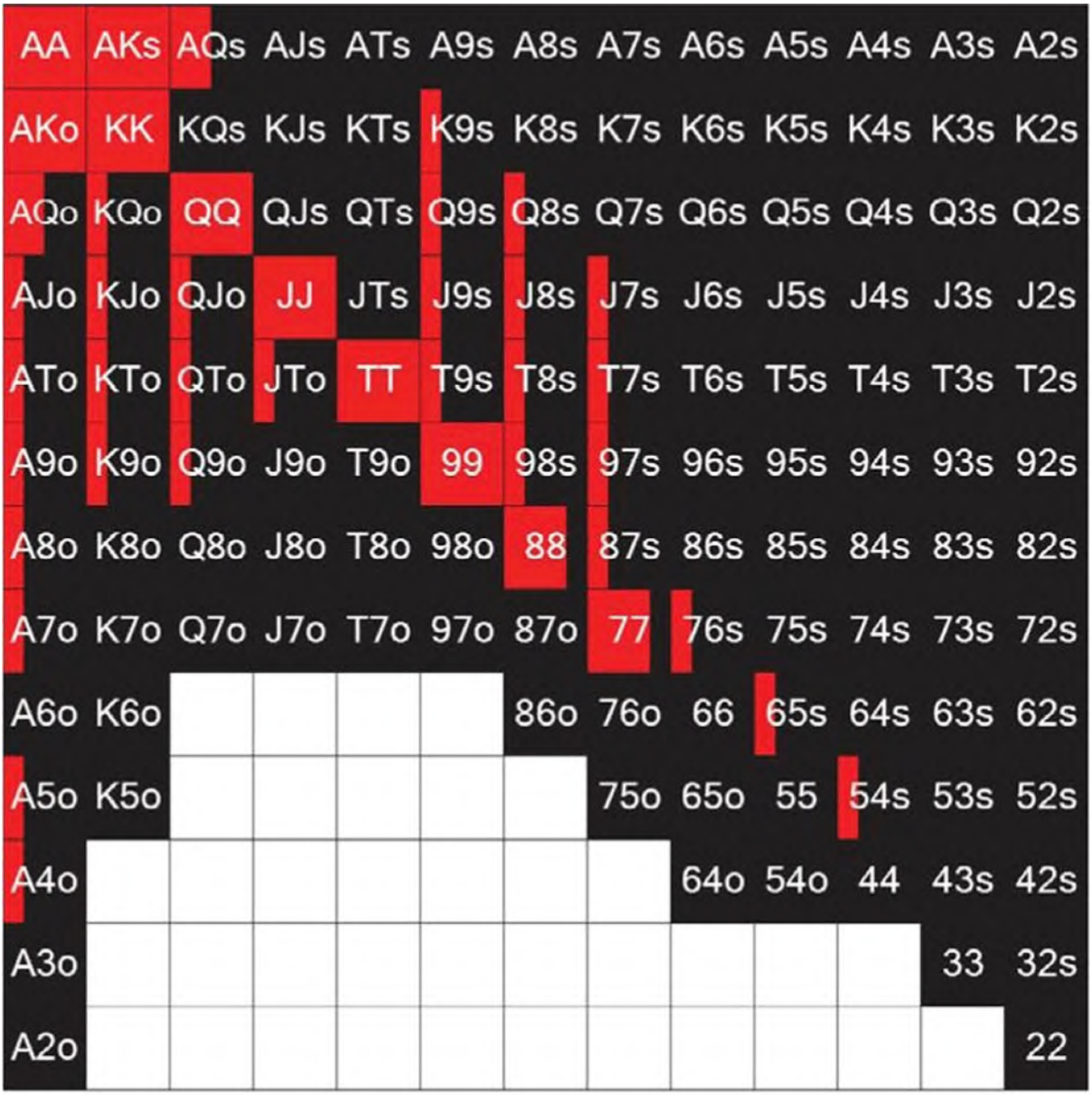
Your hand Q♣T♠ does not have enough equity to call vs this range (you will win 43% of the time but need to win 45% of the time), so you should fold.

Range Versus Range Equity

Range vs range equity is useful in post-flop scenarios where you are concerned about how each player's range gets affected by the community cards.

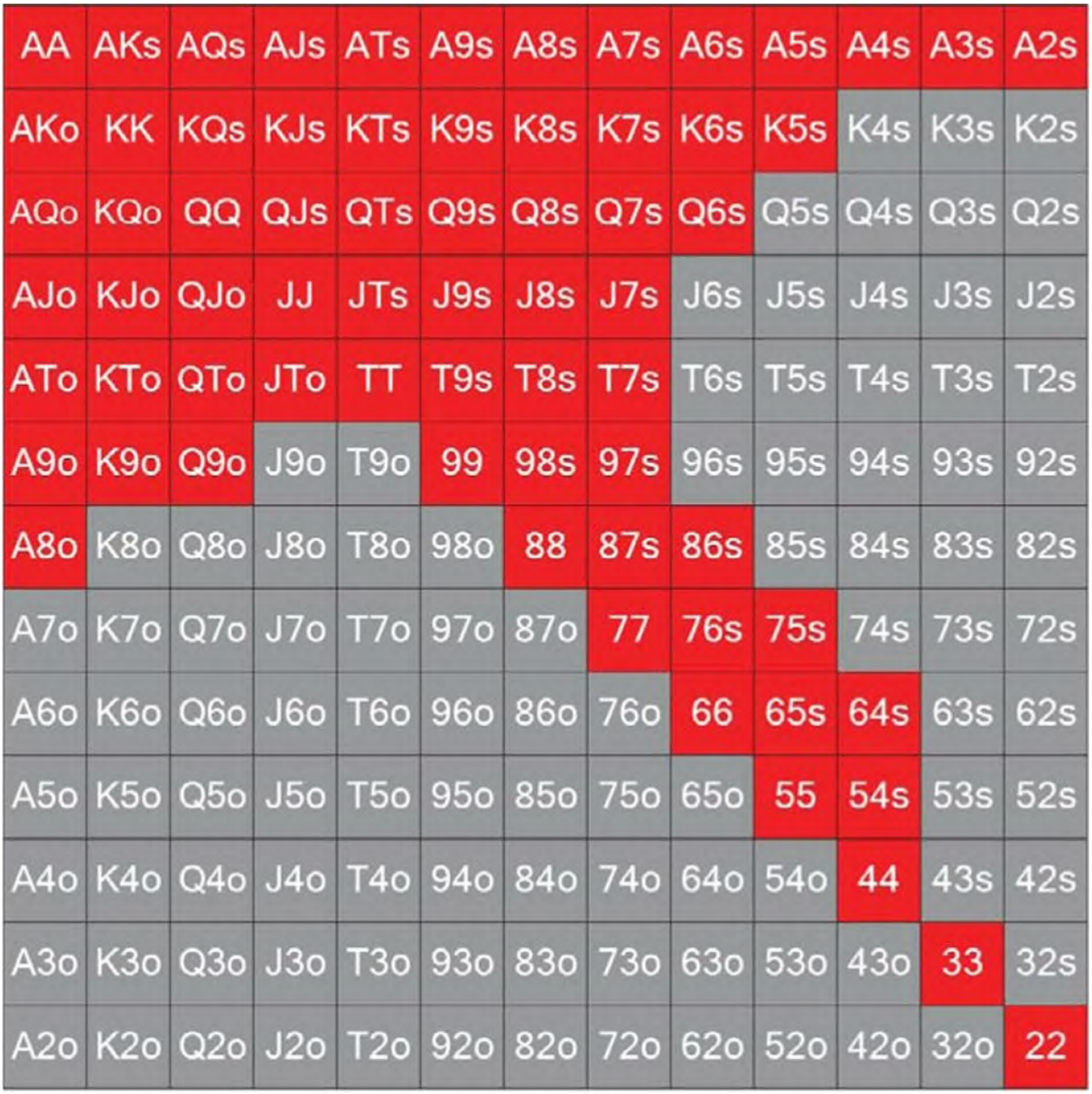
Example
Game: $109 9-max online MTT
Effective Stack: 40bb
Players: 9 (12.5% ante)
Pre-flop: (2.625bb) Play folds to you in the CO with A♦A♣ and you raise 2.25bb. Everyone folds to the BB who is a strong regular. You estimate BB defends vs CO with the following strategy *(Hand Range 7)*.

You opened a standard CO range of about 31.2% hands *(Hand Range 8)*.



Hand Range 7: BB defend vs CO 2.25x (40bb)

• 3-bet 9.7% / • Call 56.8% / • Fold 33.5%



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

Hand Range 8: CO (40bb)

• Raise 2.25x: 31.2% / • Fold 68.8%

The equity distribution on various flops of the CO 31.2% range vs BB 56.8% calling range is as follows *(Table 7)*.

	CO Equity	BB Equity	Equity Difference
Pre-flop	58.50%	41.50%	17.00%
8♥7♠5♠	49.67%	50.33%	-0.66%
A♠K♠2♦	62.16%	37.84%	24.32%
5♥4♥3♦	51.60%	48.40%	3.20%
T♥9♥8♥	56.20%	43.80%	12.40%

Table 7: Equity Distribution on Various Flops

Comparing range vs range equity, we can see that pre-flop, Hero has the advantage, but the equity distribution will change depending on the texture of the flop. It is important for Hero to understand how equities shift on various boards because that has a dramatic effect on the way the hand will play out. Let's consider a specific example with a flop of 8♥7♠5♠.

According to the equities table, this flop favors the BB. It improved their range equity from 41.5% to 50.33%, making them a tiny favorite. Your overall range equity was reduced from 58.5% to 49.67% which means that, in general, you should play much more cautiously because BB will have many high equity hands such as straights, sets, two pairs and combo draws. If you choose to c-bet the flop with a high frequency, the BB can x/r you very effectively. If you choose to check back the flop, the BB can start betting aggressively on many turns and rivers. Even if the equity of your actual hand A♦A♣ is high (70.83%) you should, in general, look to play passively and check behind with a high frequency of hands that can improve on a variety of turns, allowing them to easily call bets from the opponent.

Since A♦A♣ can call most turn bets and bluff-catch effectively, you check back. Play continues as follows:

Turn: (6.125bb) 8♥7♠5♠J♥ [2 players]
Villain bets the full pot, 6.125bb, Hero calls.

River: (18.375bb) 8♥7♠5♠J♥2♣ [2 players]
Villain moves all-in for 1.7 × Pot (31bb). Hero calls. Villain shows T♥3♥ for a busted draw.

In this spot A♦A♣ is an excellent bluff catcher. All the draws missed and you hold no hearts or spades in your hand, which makes it a little more likely Villain is bluffing because you do not block the obvious bluffing hands (flush draws).

Of course, it is impossible to memorize all possible equity matchups between hands and

ranges, or to make the exact calculations while playing. However, understanding equity is the key for poker success. You simply must spend some time working with an equity calculator in order to get familiar with some of the most common situations that you will face on a regular basis.

Knowing your own range composition is key, as each hand in your range must be played in the most profitable way possible in the context of that range.

Expected Value (EV)

EV is what you expect to win or lose on average in the long run in a given situation.

$$Ev = Long\ Term\ Expectation$$

Mathematically, EV is the sum of the probability of each possible outcome multiplied by its payoff.

$$Ev = [\%W * \$W] - [\%L * \$R]$$

Where:
%W = How often you win; in other words, your equity in the pot
$W = How much money you can win
%L = How often you lose; in other words, 100% – your equity
$R = How much money you have to risk by taking the action

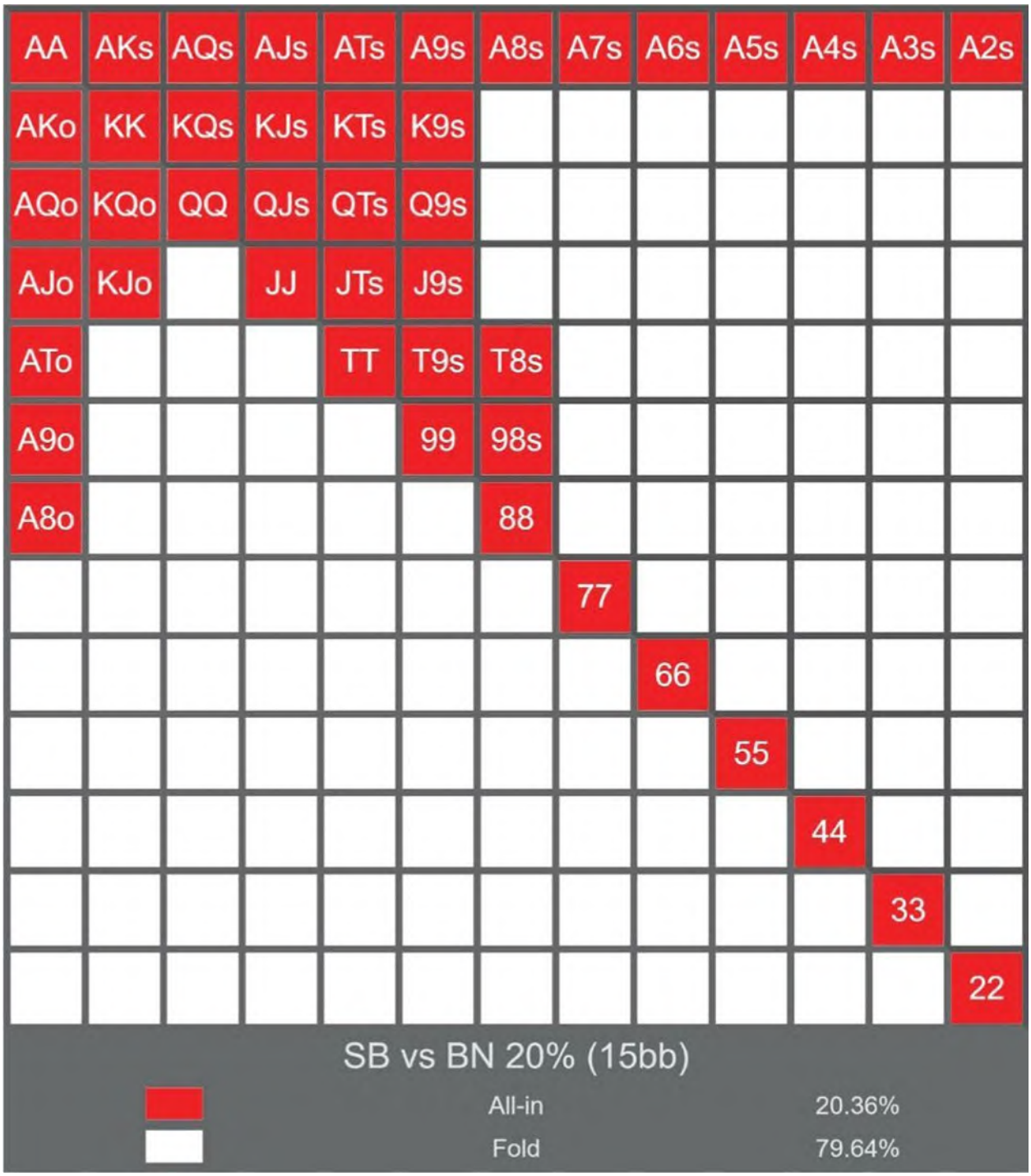
- ♦ If the result of this equation is a positive number, the play has a positive expectation (+EV) and will win money in the long run.
- ♦ If the result of this equation is a negative number, the play has a negative expectation (-EV) and will lose money in the long run.
- ♦ If the result of this equation is zero, the play has a neutral expectation (0EV) and will break even in the long run.

By definition, the *EV of folding is always zero*. Once money has been put into the pot it no longer belongs to you. The EV calculation starts from the point you decide your next action. Therefore, as folding does not put any more money at risk, the EV of folding is 0.

EV calculations are very powerful because they dictate how the game should be played. If players knew the exact EV of each action for every single spot, playing would be trivial as all they would have to do is always choose the highest EV option.

Example
Game: $100 3-max online Jackpot Sit & Go
Stacks: BN 35bb, SB 15bb, BB 25bb
Players: 3 (no ante)
Pre-flop: (1.5bb) Hero is in the BN with A♠5♠
Hero raises 2x, SB is a regular who goes all-in for 15bb. BB folds and the action gets back to Hero who has a decision.

Take your time and analyze the parts of the EV equation one by one.
Villain is a regular, so you can assign them a standard 20% rejamming range *(Hand Range 9)*.



Hand Range 9: A Standard SB 20% Rejamming Range vs BN

Using an equity calculator, you will see that your A♠5♠ has 43.31% equity vs the SB range. So,

%W = 43.31%

You can win the SB stack of 15bb plus the dead money (the big blind plus 2bb that you raised). So,

$$\$W = 15+1+2 = 18bb$$

The frequency with which you lose the pot is:

$$\%L = 100\% - 43.31\% = 56.69\%$$

The amount you need to call is:

$$\$R = 13bb$$

Putting this all together:

$$Ev = [43.31\% * 18bb] - [56.69\% * 13]$$

$$Ev = [7.80] - [7.4]$$

$$Ev = 0.4bb$$

You decide to call with A♠5♠ because it is the higher EV option. When you call, you have an EV of 0.4 and when you fold, you have an EV of 0.

Win Rate

Another way to visualize EV is in big blinds won or lost per 100 hands (bb/100). Since we are calculating EV in big blinds, all that is needed is to multiply EV by 100 (EV × 100).

Poker winnings should be measured over the long run. The ability to consistently make better decisions allows the best players to win in the long run. They take the highest EV action over and over again.

As seen in this example, a player who calls every time with A♠5♠ will make on average 40 big blinds per every 100 hands more than a player who always folds.

$$Win\ Rate = 40^{bb}/100$$

Even if 0.4bb might seem like a small reward-to-risk for calling Villain's all-in for a big

portion of your stack, it is these small edges, taken over thousands of hands, that make the difference between a world-class player and a rookie. Over the course of a lifetime, these edges materialize into hundreds of thousands, or even millions of dollars.

Knowing the hand equity vs Villain's range can help us predict EV and make better decisions.

EV Rescaled

It is often useful to think of EV as a fraction of the pot:

$$\%Ev = \frac{Ev}{Pot}$$

Example
The Pot is $150 and you are given the EV of two different actions, A and B:

EV(A) = $75
EV(B) = $100

The EV rescaled of both actions is:

$$\%Ev(A) = \frac{75}{150} = 50\%$$

$$\%Ev(B) = \frac{100}{150} = 67\%$$

Action B captures 17% more of the pot than Action A, making it definitively the better option.

Fold Equity (FE)

Fold equity represents the extra equity you stand to gain from the likelihood of your opponent folding to a bet.

$$Fold\ Equity = (Probability\ \ Villain\ Folds) * (Villain's\ Hand\ Equity)$$

$$Total\ Equity = Fold\ Equity + Hand\ Equity$$

Example
Game: $215 Online Tournament
Effective stack: 100bb
Players: 9 (no ante)
Pre-flop: (1.5bb) Hero is in the CO with 8♦7♦ and raises to 2.2bb. Play folds to the BB who calls with 3♦3♥.
Flop: (4.9bb) A♠K♠5♣ [2 players]
BB checks. What should Hero do?

In this example, the BB has 71% equity with the small pair while Hero has 29%. However, if you bet this flop, you can realistically expect Villain to fold over 75% of the time with their junky holding. So, using our FE formulas we have:

$$Fold\ Equity = (75\%) * (71\%) = 53\%$$

$$Total\ Equity = 53\% + 29\% = 82\%$$

However, the term *Fold Equity* is often used in a less technical sense, simply to refer to the chance of getting a player to fold.

Example
Game: $109 9-max online MTT
Stacks: BN 35bb, SB 25bb, BB 15bb
Players: 9 (12.5% ante)
Pre-flop: (2.625bb) Hero is in the BB with T♦5♣
BN raises 2bb. He is an overly aggressive player who plays too many hands but tends to give up when facing resistance. SB folds, and Hero has a decision.

Your hand is pretty bad and you would normally just fold it against a regular opponent. However, you know Villain plays too many hands from the BN. Since a wide range of hands is more difficult to defend vs re-raises, you suspect Villain might be over-folding (folding too

often) if you move all-in in this spot. So, *how much fold equity do you need to go all-in profitably with T♦5♣?*

To answer this question, you can use the EV equation making EV = 0 and %Villain Folds = FE

$$Ev = [(Ev\ of\ Fold) * (\%\ Villain\ Folds\ )] + [(Ev\ \ Called) * (\%\ Villain\ Calls)] + [(Ev\ Reraised) * (\%\ Villain\ Raises)]$$

Now analyze each part of the equation.

When Villain folds you get to win the entire pot:

$$(Ev\ of\ Fold) = Initial\ Pot = The\ Blinds\ and\ Antes + Villain's\ Raise = 4.625bb$$

Since you are moving all-in, Villain can no longer re-raise you. So,

$$[(Ev\ Reraised) * (\%\ Villain\ Raises)] = 0$$

and

$$\%\ Villain\ Calls = (1 - FE\ )$$

If you get called, you will play for a total pot of 31.625bb. You are risking an extra 14bb and estimate T♦5♣ will have about 31% equity vs the Villain's calling range.

$$Ev\ Called = [Total\ Pot * Our\ Hand\ Equity\} - Risk$$

$$Ev\ Called = [31.625 * 0.31\} - 14 = \ -4.19$$

Putting everything together:

$$0 = [(Ev\ of\ Fold) * (FE\ )] + [(Ev\ Called) * (1 - FE\ ]$$

$$0 = [(4.625) * (FE\ )] + [(-4.19) * (1 - \ FE)\ ]$$

$$0 = 4.625FE - 4.19 + \ 4.19FE$$

$$0 = [(Ev\ of\ Fold) * (FE\ )] + [(Ev\ Called) * (1 - FE\ ]$$

$$0 = [(4.625) * (FE\ )] + [(-4.19) * (1 - FE)\ ]$$

$$0 = 4.625FE - 4.19 + 4.19FE$$

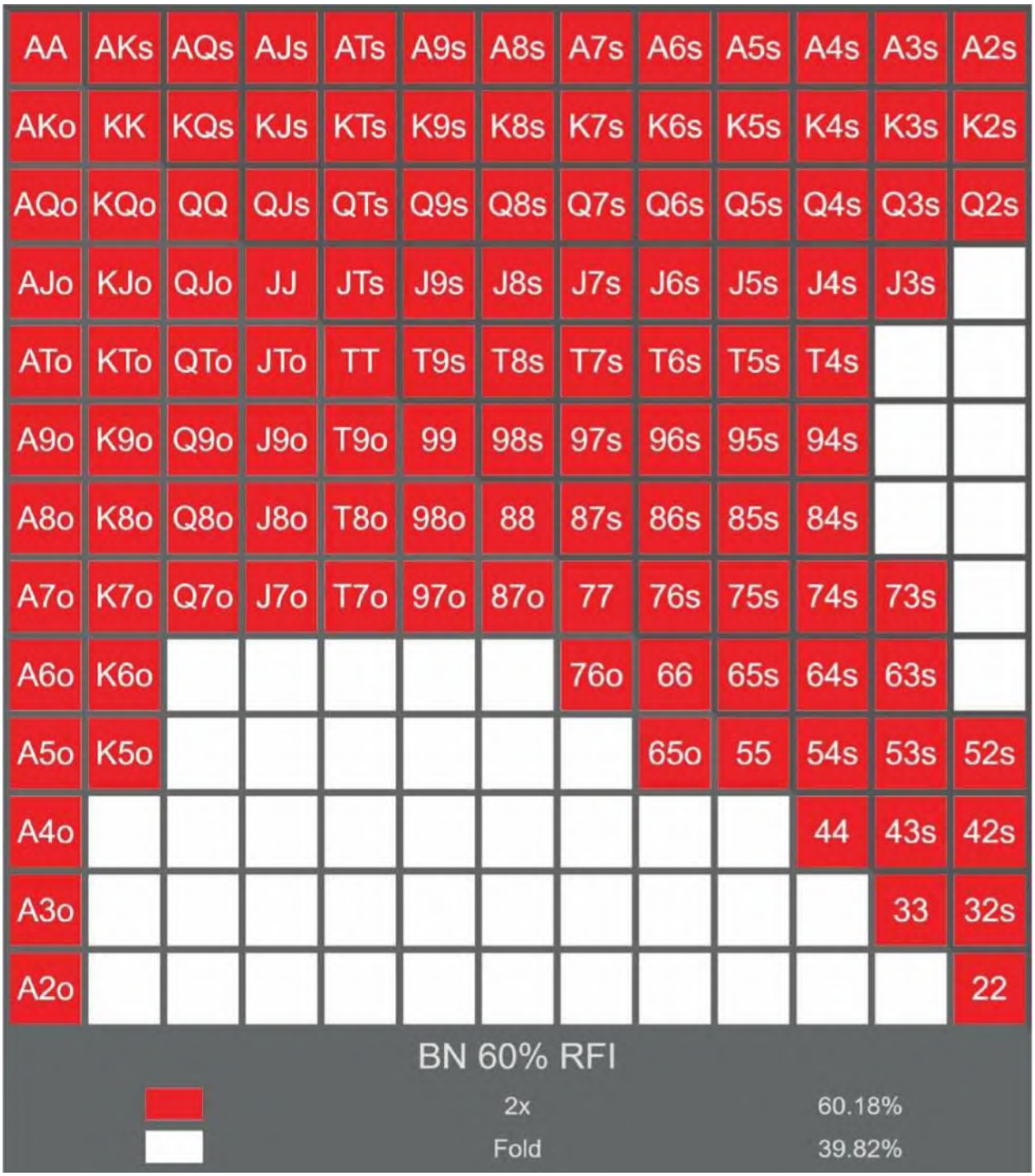
$$0 = 8.82FE - 4.19$$

$$8.82FE = 4.19$$

$$FE = \frac{4.19}{8.82} = 0.47 = 47\%$$

You need at least 47% fold equity to go all-in profitably with T♦5♣.

You estimate Villain is opening ~60% hands on the BN *(Hand Range 10)* and calling the BB all-in with 28.8% hands *(Hand Range 11)*.



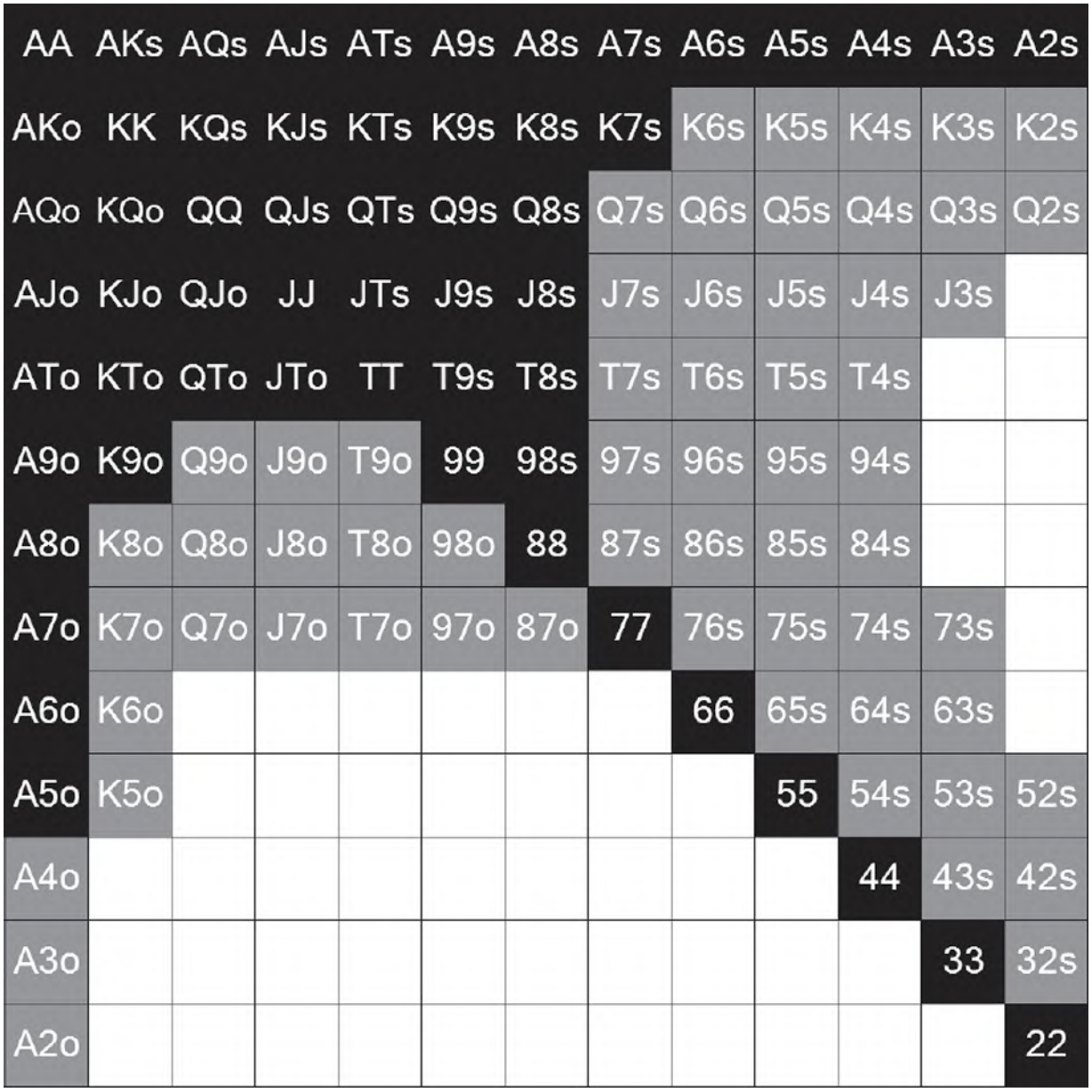
Hand Range 10: 60% BN Opening Range

BN Calling Frequency:

$$Calling\ Frequency = \frac{Calling\ \%}{Opening\ \%}$$

$$Calling\ Frequency = \frac{28.8}{60}$$

$$Calling\ Frequency = 0.48 = 48\%$$



Hand Range 11: BN Open vs BB Rejam (15bb)

• Call 48% / • Fold 52%

The BN Folding Frequency is:

$$BN\ Folding\ Frequency = 100\% - Calling\ Frequency$$

$$BN\ Folding\ Frequency = 100\% - 48\% = 52\%$$

The minimum fold equity needed is 51% and Hero has 52%. So, moving all-in with T♦5♣ is a

(barely) profitable play.

Hand Playability

If there were no betting in poker and players were forced to go all-in every hand, the expected value for each player would be their hand equity × the pot.

$$Ev = Eq * Pot$$

Example
In a heads-up gambling game each player has to ante $100 and there is no future betting. Player1 gets dealt 4♦4♠ and Player2 gets 9♥8♥.
What is the expected payoff for each player?

The equity of 4♦4♠ = 47.26%

$$Player1\ Ev = 47.26\% * \$200 = \$94.52$$

The equity of 9♥8♥ = 52.74%

$$Player2\ Ev = 52.74\% * \$200 = \$105.48$$

In this toy game both players get to realize 100% of their equity. However, in real poker games where betting happens across multiple streets, if a player folds before showdown, they give up equity in the pot which is transferred to the remaining players. This dynamic is known as equity realization.

Equity Realization (EqR)

Equity realization refers to the fraction of equity that is materialized in EV. Hands that capture a bigger percentage of the pot than their equity share are said to over-realize their equity. Hands that capture a smaller percentage of the pot than their equity share are said to under-realize their equity.

Example

Game: $55 9-max online MTT
Stacks: UTG 50bb, BB 40bb
Players: 9 (12.5% ante)
Pre-flop: (2.625bb) UTG is a regular who raises 2bb. Everyone folds to Hero in the BB with 9♣5♦ who now has a decision.

As UTG is a regular, you assume they are opening a standard 16% range *(Hand Range 12)* that can easily defend vs 3-bets, so 3-bet bluffing with 9♣5♦ is out of the question. The decision is between calling and folding.

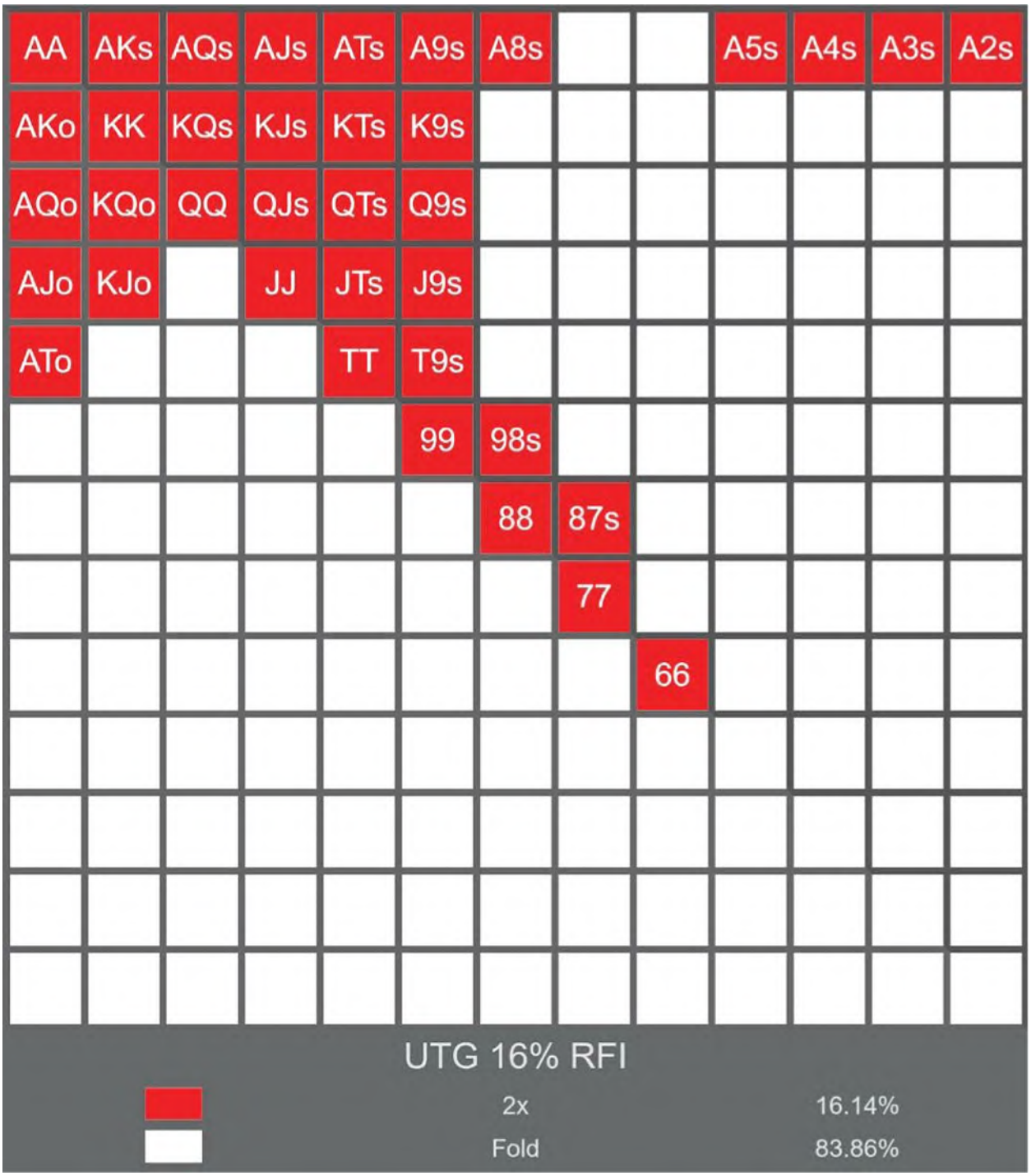
If you were calling for all of your chips, the solution would be to simply compare the pot odds to your hand equity and call if your hand equity were greater than the pot odds.

9♣5♦ equity vs UTG range = 29.5%

$$Pot\ Odds = \frac{Risk}{Risk + Reward}$$

$$Pot\ Odds = \frac{1bb}{1bb + (2.625bb + 2bb)} = \frac{1}{5.625} = 18\%$$

Clearly your hand equity is a lot better than the pot odds. However, as you are not all-in, if you make the call you will have to play post-flop where different outcomes can occur. Villain can bet aggressively and sometimes force you to fold the best hand. Villain can make a stronger hand than yours and you can lose a big pot. You could flop a premium hand but get no action, or even occasionally stack the Villain. Unfortunately, raw equity (the equity as if you were all-in) does not account for any of these possibilities.



Hand Range 12: UTG 16% Opening Range

How can you know if your call is +EV if you have no idea of the type of situation you will end up facing?

The equity realization factor tells you how much equity you can expect to realize on average

across all possible scenarios. So, if you know both a hand equity (Eq) and equity realization factor (EqR), you can calculate the hand expectation for more complex scenarios, including post-flop play.

$$Ev\ Call = EqR(Eq * Pot)$$

Conversely, if you know the Eq and EV, you can solve the equation for EqR:

$$EqR = \frac{Ev}{(Eq * Pot)}$$

Rescaling EV to %EV:

$$\frac{Ev}{Pot} = \%Ev$$

Equity realization simplified formula is:

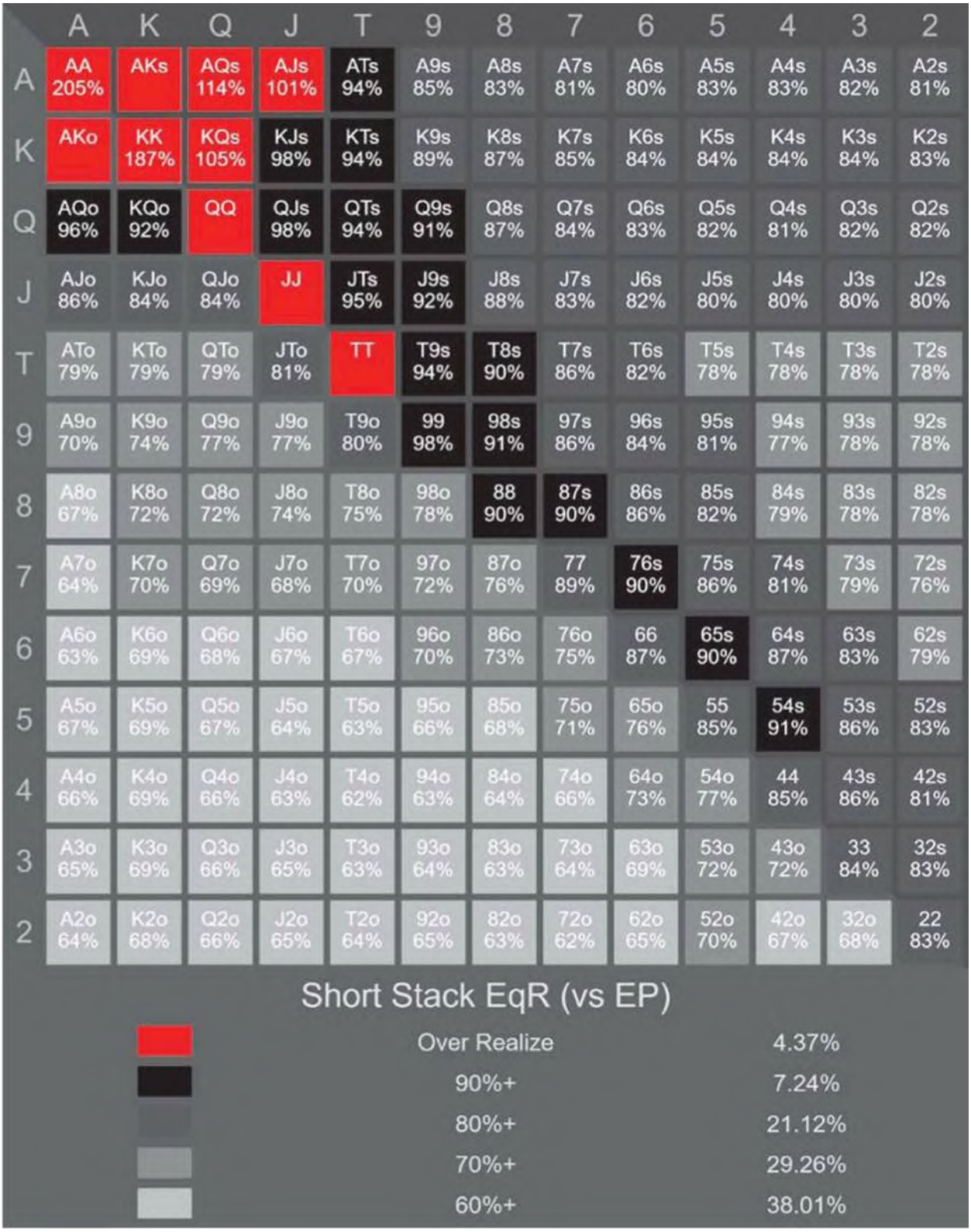
$$EqR = \frac{\%Ev}{Eq}$$

Calculating the EqR for each poker hand for every single spot is almost impossible, as it would essentially require having the solution to the entire game of poker. However, there are a couple ways you can get very good approximations.

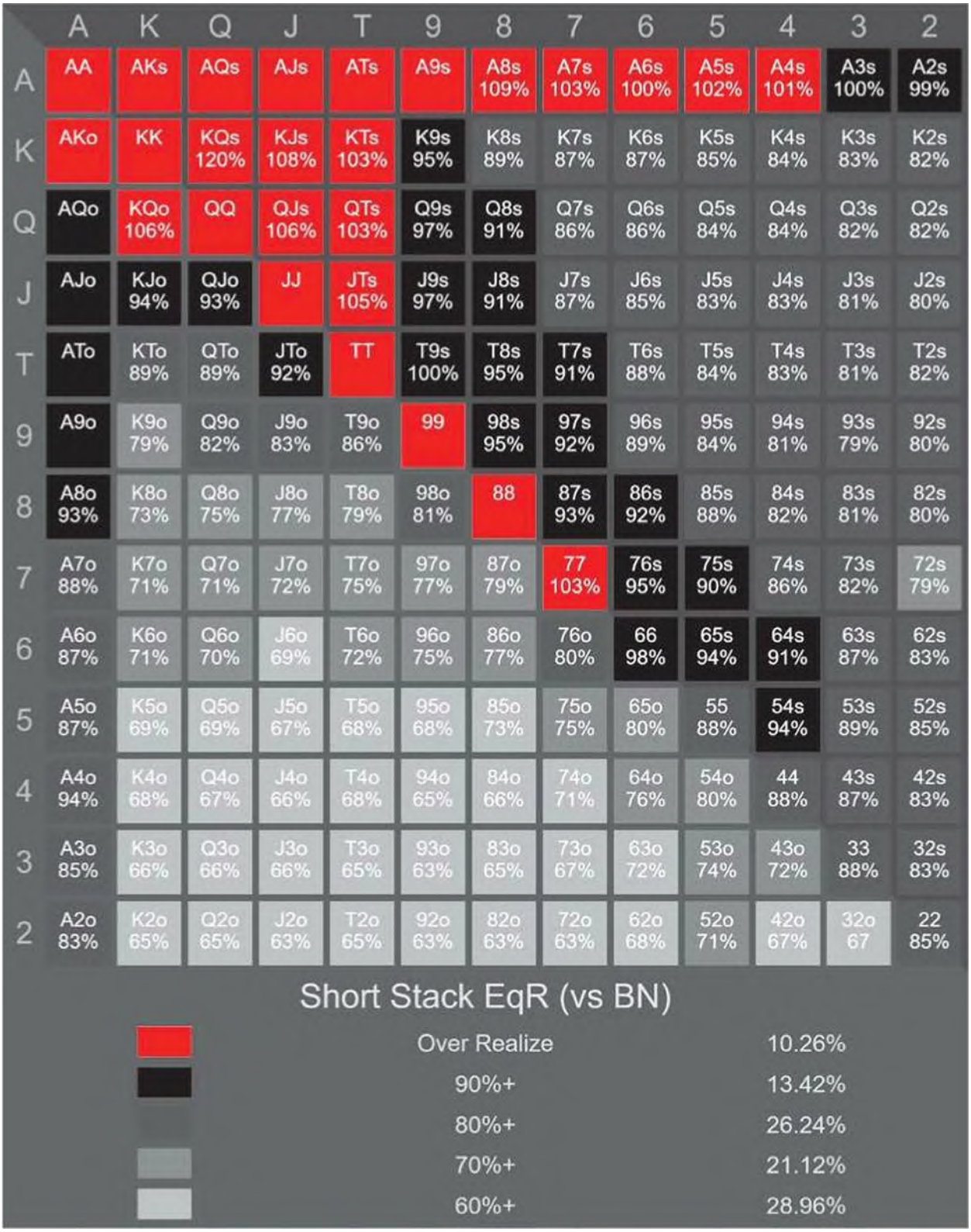
- ♦ You can use empirical data by taking a sample of millions of hands played in online games to compare their equity to the fraction of the pot they capture in every spot.
- ♦ You can use modern solvers to obtain the EqR of each hand in various spots and average the results.

Equity Realization Heatmaps

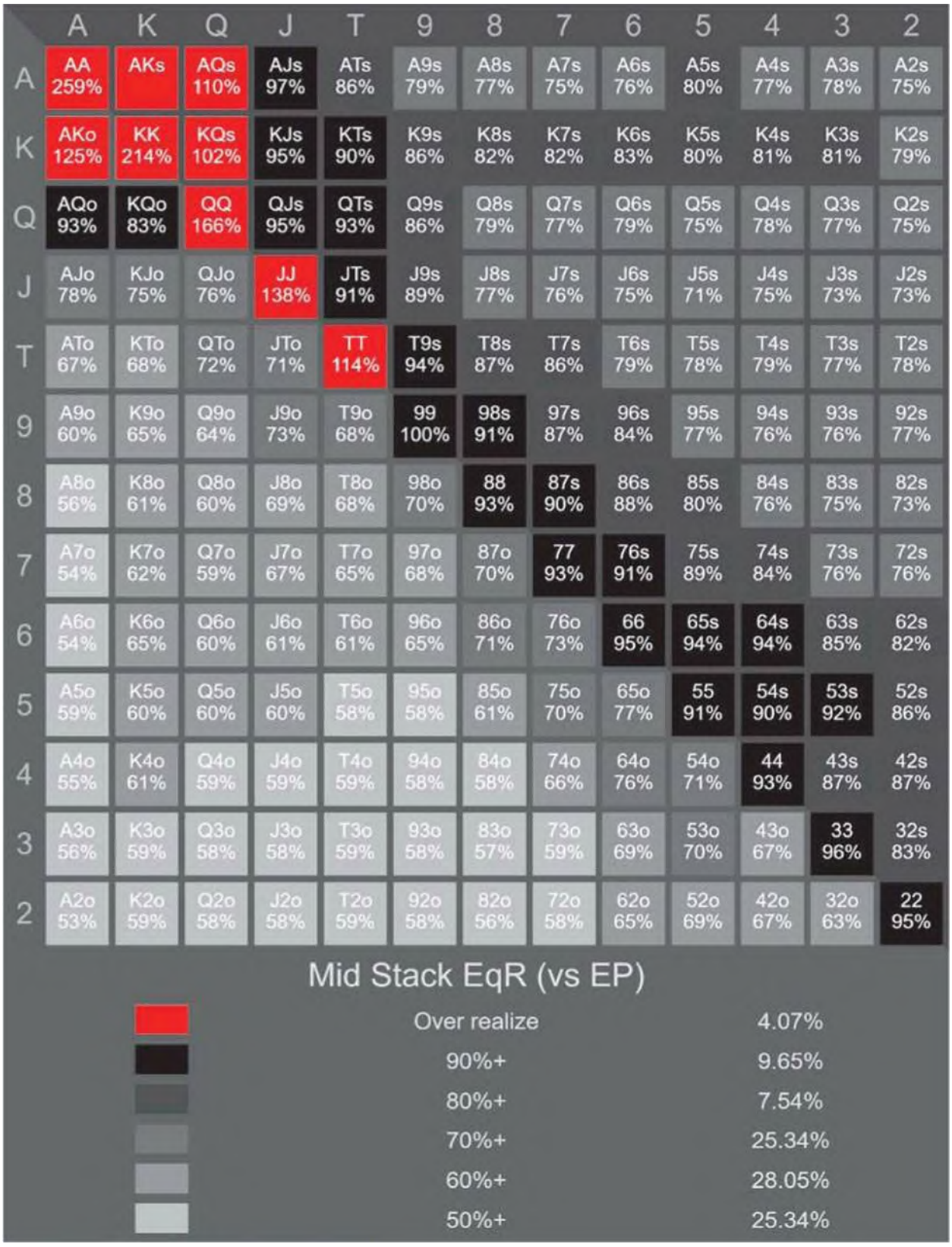
The following equity realization heatmaps *(Heatmaps 1-4)* were generated by Pio Solver. They show results for situations where the BB is playing a single raised pot against either an EP or the BN in short stack and mid stack scenarios and they account for a 12.5% ante.



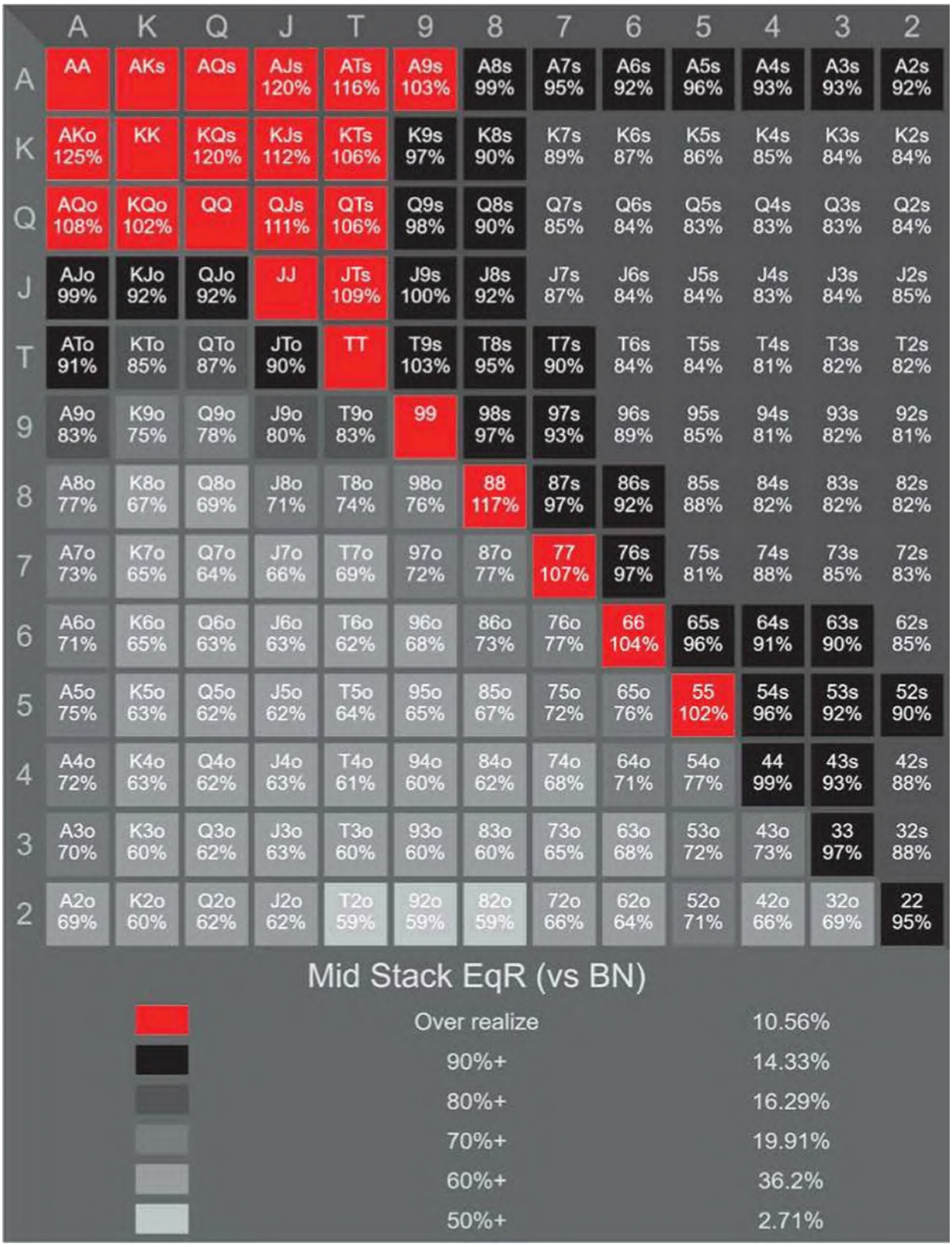
Heatmap 1: Equity Realization (10-20bb) vs EP



Heatmap 2: Equity Realization (10-20bb) vs BN



Heatmap 3: Equity Realization (30-75bb) vs EP



Heatmap 4: Equity Realization (30-75bb) vs BN

Going back to the example with 95o, input the EqR factor from heatmap number 3 into the EV equation:

$$Ev\ Call = EqR(Eq * Pot) - Risk$$

$$Ev\ Call = 0.58(0.295 * 4.625) - 1$$

$$Ev\ Call = -0.21bb$$

This shows that calling with 9♣5♦ has a negative expectation and therefore should be folded (despite the fact that it has enough raw equity to justify calling).

Another way to tackle this problem is to start by finding out how much equity the hand 9♣5♦ needs to realize for the call to break even:

$$Min\ EqR = \frac{Pot\ Odds}{Hand\ Equity}$$

$$Min\ EqR = \frac{18}{29.5}$$

$$Min\ EqR = 61\%$$

9♣5♦ has an EqR factor of 58%, which is 3% lower than the minimum 61%.That means that even if we have a lot of equity, we just can't realize enough of it post-flop to make this call profitable.

Elements that Affect Hand Playability

Position

The importance of position is something that almost all poker players understand to at least some extent. Ever since they began playing, they have been told to avoid playing out of position and

how playing in position is a lot easier, but what they are not told is *why having position is so important.*

When you are in position, you have the advantage of acting last on every street for the rest of the hand, which means you get to see what you opponent does and can react accordingly. Most importantly, if your opponent checks to you, you can check behind and are guaranteed a free card, which makes a huge difference in terms of realizing equity IP compared to OOP. After checking OOP, you will often face a bet and be forced to fold, denying your equity in the pot.

Hand Strength

If a hand has a lot of raw equity, equity realization becomes less of an issue because high equity hands are happy, in most circumstances, to play big pots. They also provide a lot of flexibility because you can either call or raise with them.

Very low equity hands are also easy to play because, most of the time, the correct play is to just fold.

Medium strength hands are the truly difficult ones to play, because they desperately want to get to showdown or see free cards but struggle to continue if the opponent applies a lot of pressure.

Hand Suitedness

On average, suited hands realize 16% more equity than offsuit hands due to having access to both front and backdoor flush draws. This gives them a lot of flexibility to either semi-bluff more effectively or call bets with higher implied odds.

Hand Connectedness

Offsuit hands with no connectivity, such as Q2o, are among the lowest EqR hands. They are incredibly difficult to play because they flop either high pairs with no kicker or low pairs and their drawing capabilities are limited. Therefore, realizing equity with them is quite difficult.

Range Advantage

Having the range vs range equity advantage can help the weaker hands in your range realize their equity because, if your range is strong compared to your opponent’s, they simply cannot bet too aggressively. This allows the weaker hands in your range, that would struggle to withstand a bet, to see more free cards.

Stack to Pot Ratio (SPR)

SPR is the effective stack size divided by the size of the pot:

$$SPR = \frac{Stack}{Pot}$$

Knowing how big your stack is relative to the pot is crucial. It allows you to plan ahead and tailor your bet sizes to put yourself in a favorable SPR situation according to the ranges in play. *Table 8* shows typical SPR in MTTs with a 12.5% ante.

Stack Depth	SPR		
	Single Raised Pot	3-bet Pot	4-bet Pot
300bb	44.91	15.68	5.45
250bb	37.36	12.99	4.46
200bb	29.81	10.31	3.48
150bb	22.26	7.62	2.49
100bb	14.72	4.94	1.88
75bb	10.94	3.60	1.48
65bb	9.43	3.06	1.22
45bb	6.42	2.23	na
30bb	4.53	1.38	na
25bb	4.09	1.58	na
20bb	3.20	1.19	na
18bb	2.84	na	na
15bb	2.31	na	na
12bb	1.78	na	na
10bb	1.42	na	na

Table 8: Typical SPR in MTTs with 12.5% Ante

General SPR Guidelines

- **Low SPR (0-5):** Hands that can flop made hands such as top pairs and overpairs do better in low SPR pots than speculative hands that tend have difficulty realizing their equity due to the lack of fold equity and lower implied odds.

- **Medium SPR (6-11):** The value of top pair type hands becomes demoted and the value of speculative hands increases. The equity realization of hands starts to revolve more around suitedness and connectedness than high card value.

- **High SPR (11+):** As stacks get deeper and deeper, more of a hand's value comes from its potential to make the nuts (nuttiness). Hands such as sets, nut draws, high flushes and straights, that offer the possibility of coolering your opponent, increase in value. Single pair type hands will struggle to get to showdown in large pots unless they have some sort of backup equity.

Range Morphology

Hand ranges can be categorized according to their equity distribution vs the opponent's range.

Linear Range

A linear range is composed of the highest equity hands without gaps in between. Here is an example *(Hand Range 13)*.

Polarized Range

A polarized range consists of high equity value hands and low equity bluffing hands. A range is said to be perfectly polarized if it consists of only nuts and bluffs, with no hands in between. Here is an example *(Hand Range 14)*.

Hand Range 13: Hands with at Least 60% Equity Versus a Random Hand

Hand Range 14: Hands with Over 65% or Less Than 40% Equity Versus a Random Hand

Depolarized/Condensed Range

A condensed or depolarized range is the opposite of a polar range. It has the top and bottom hands removed and is comprised of middle equity hands. An example is seen in *Hand Range 15*.

Capped/Uncapped Range

When a range is missing the strongest hands (the top end), it is said to be capped. Conversely, if the range has all strong hands in it, it is said to be uncapped.

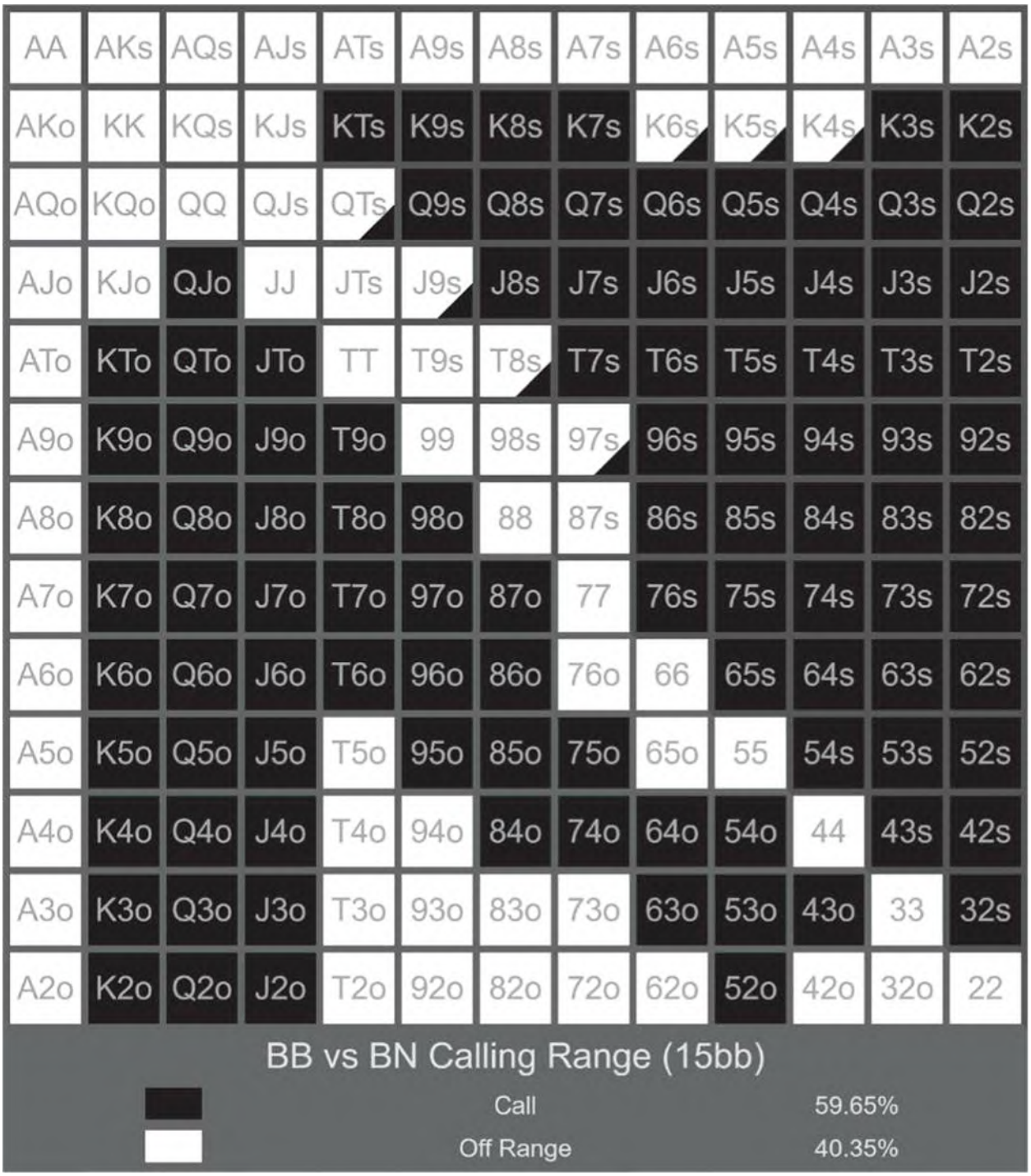
Example
Game: $215 9-max online MTT
Stacks: BN 25bb, BB 15bb
Players: 9 (12.5% ante)
Pre-flop: (2.625bb) BN raises to 2bb, SB folds and the BB calls.
Flop: (5.625bb) A♥J♦T♠ [2 players]

On the A♥J♦T♠ flop, the BB range *(Hand Range 16)* lacks all nut hands such as straights (KQ), sets (AA, JJ, TT), and most two pairs (AJ-AT), so this range is said to be *capped***.** Conversely the BN range *(Hand Range 17)* is *uncapped* because it has all of those hands in its range.

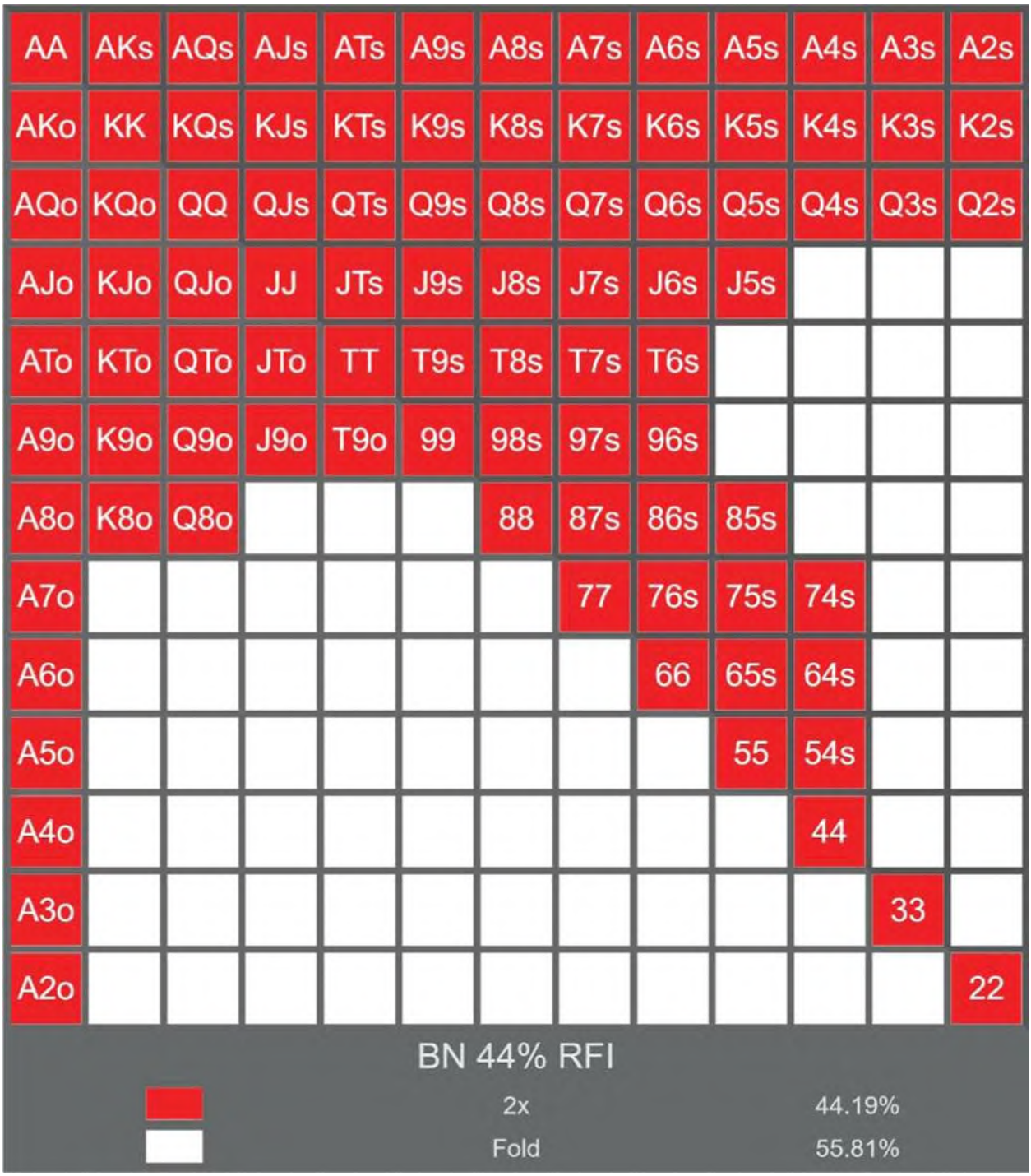
	A	K	Q	J	T	9	8	7	6	5	4	3	2
A	85.2%	67%	66.2%	65.4%	64.6%	62.8%	61.9%	61%	59.9%	59.9%	59%	58.2%	57.4%
K	65.3%	82.4%	63.4%	62.6%	61.8%	60%	58.3%	57.5%	56.6%	55.8%	54.9%	54.1	53.2%
Q	64.4%	61.5%	79.9%	60.3%	59.5%	57.7%	56%	54.3%	53.6%	52.8%	51.9%	51%	50.2%
J	63.6%	60.6%	58.1%	77.5%	57.5%	55.7%	54%	52.3%	50.6%	50%	49.1%	48.2%	47.4%
T	62.7%	59.7%	57.3%	55.2%	75%	54%	52.3%	50.6%	48.9%	47.2%	46.5%	45.7%	44.8%
9	60.8%	57.8%	55.4%	53.3%	51.5%	72%	50.8%	49.1%	47.4%	45.7%	43.9%	43.3%	42.4%
8	59.9%	56%	53.6%	51.5%	49.7%	48.1%	69.2%	47.9%	46.2%	44.5%	42.7%	40.9%	40.3%
7	58.8%	55.2%	51.8%	49.7%	47.9%	46.3%	45.1%	66.2%	45.4%	43.7%	41.8%	40%	38.2%
6	57.7%	54.2%	51%	47.8%	46.1%	44.5%	43.2%	42.3%	63.3%	43.1%	41.3%	39.5%	37.7%
5	57.7%	53.3%	50.1%	47.2%	44.3%	42.7%	41.4%	40.5%	39.9%	60.3%	41.5%	39.7%	37.8%
4	56.7%	52.3%	49.1%	46.2%	43.5%	40.7%	39.4%	38.6%	38%	38.1%	57%	38.6%	36.8%
3	55.8%	51.4%	48.2%	45.3%	42.6%	40%	37.5%	36.6%	36%	36.3%	35.1%	54%	36%
2	54.9%	50.5%	47.3%	44.3%	41.7%	39%	36.8%	34.6%	34%	34.3%	33.2%	32.3%	50.3%

Condensed Range

Hand Range 15: Hands with Between 40% and 65% Equity Versus a Random Hand



Hand Range 16: A Capped Range



Hand Range 17: An Uncapped Range

A condensed range is capped, but a capped range isn't necessarily condensed. For example, if the flop were 5♥4♦3♠, then the big blind range would be condensed but would contain very strong hands such as straights and two pairs, so it wouldn't be capped.

Caveat: In real poker games, ranges are rarely perfectly polar, perfectly linear, or any other precise category. In most situations, they will be a mix of the various range types.

02

THE ELEMENTS OF GAME THEORY

The Core Concepts

The following are important concepts that will be used throughout this book when discussing game theory.

Game Theory: A whole field of math and science that studies mathematical models of conflict or cooperation between intelligent, rational decision makers. It can be applied to economics, military tactics, politics, psychology, biology, computer science, and card games like poker.
Game: Any interaction between multiple people called players in which each player's payoff is affected by the decisions made by others.
Utility: The overall measure of happiness players get from specific outcomes. Higher utility numbers imply that the outcome is preferred.
Zero-Sum Game: A mathematical representation of a situation in which a participant's gain or loss in utility is exactly balanced by the losses or gains of the other participants. If the total gains of the participants are added up and the total losses are subtracted, they will sum to zero. (Poker is a zero-sum game if we neglect rake and ICM [Independent Chip Model] used at tournament final tables and SNGs; this will be studied later in the book.)
Strategy: A full specification of a player's behavior, describing each action a player would take at every possible decision point throughout the game.
Pure Strategy: A strategy in which the same action is always taken at the same decision point.
Mixed Strategy: A strategy that involves playing more than one pure strategy some frequency of the time at the same decision point.

Dominant Strategy: When one strategy yields a higher payoff than some other strategy, regardless of which strategy the other players choose. A strategy is *dominated* if, regardless of what any other players do, the strategy earns a player a smaller payoff than some other strategy.

For two different strategies *A* and *B.*

- **B strictly dominates A** if choosing *B* always gives a better outcome than choosing A, no matter what the other player(s) do.
- **B weakly dominates A** if there is at least one set of opponents' actions for which *B* is superior than *A,* and all other sets of opponents' actions give *B* the same payoff as *A.*
- **B is strictly dominated by A** if choosing *B* always gives a worse outcome than choosing *A,* no matter what the other player(s) do.
- **B is weakly dominated by A** if there is at least one set of opponents' actions for which *B* gives a worse outcome than *A,* while all other sets of opponents' actions give *A* the same payoff as *B.*
- **B and A are intransitive** if *B* neither dominates A, nor is dominated by *A.* Choosing *A* is better in some cases, while choosing *B* is better in other cases, depending on the opponents' actions.

Maximally Exploitative Strategy

A Maximally Exploitative strategy is the most profitable response (set of actions) to an opponent's fixed strategy. To calculate an MES you must know the opponent's full strategy. You can find an MES by finding the most profitable way to play each particular hand individually. Once that is known, the value of the whole game is the aggregate of the EV of each individual hand.

If you figure out the most profitable play with each one of the 1,326 Hold'em hand combinations, you have found the MES. Since each hand is always played in the most profitable way, for a hand to be played in two or more different ways (mixed strategy), the EV of each action must be the same. Consider the following simplified poker situation.

Example

Game: Heads-Up Sit N' Go *(Players can only push or fold)*
BN Stack: 100 chips
BB Stack: 100 chips
Blinds: (5/10)
Pre-flop: BN is playing a strategy where he goes all-in with *all of his hands*. What is the BB's MES vs the BN?

Using the pot odds formula:

$$Pot\ Odds = \frac{Risk}{Risk + Reward}$$

$$Pot\ Odds = \frac{90}{90 + 110} = \frac{90}{200} = 0.45 = 45\%$$

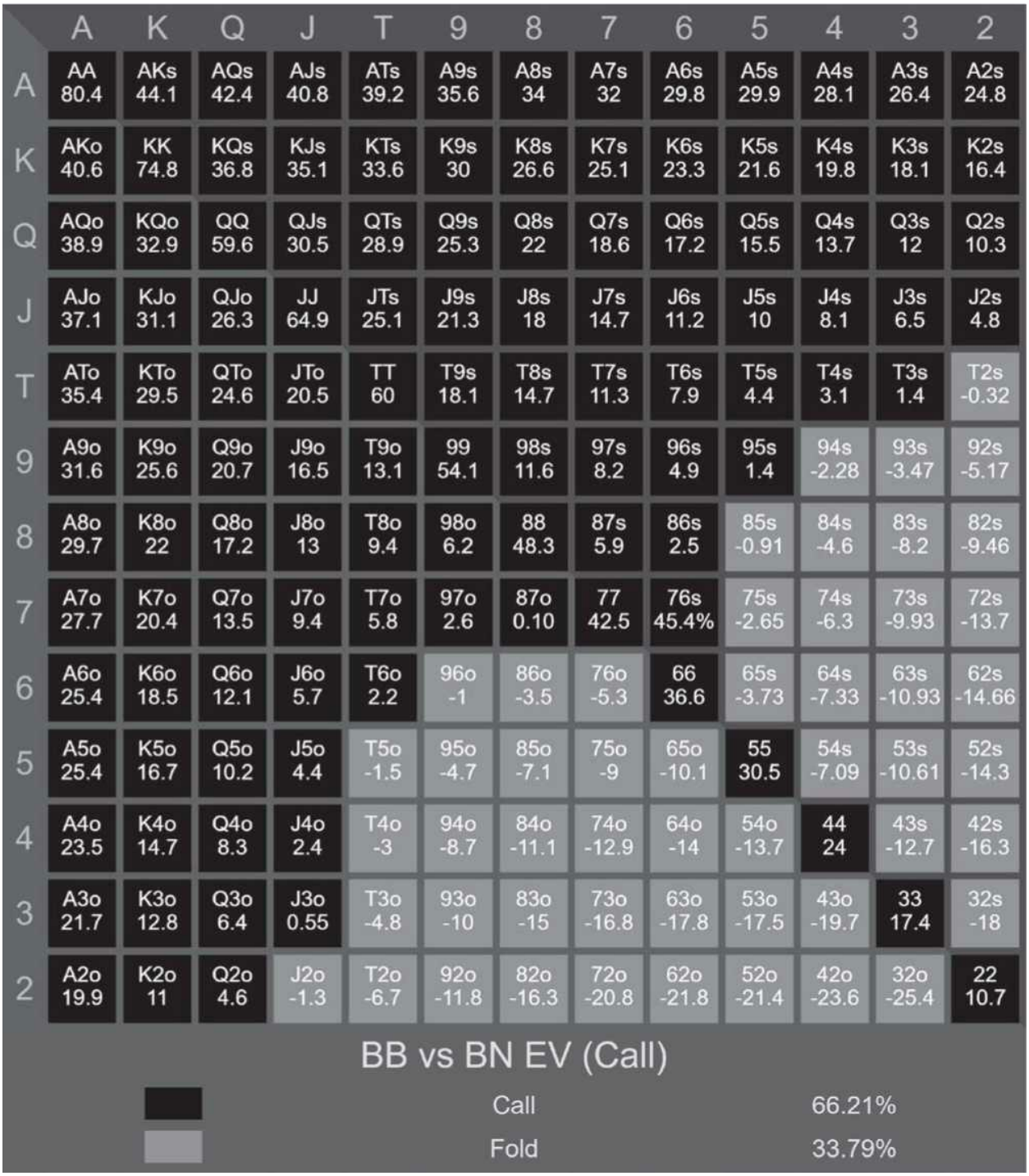
BB can call all hands that have at least 45% equity vs Villain's range, so BB's MES vs BN is to call 66.21% hands and fold 33.79% *(Hand Range 18)*.

Hand Range 18: A Calling Range with at Least 45% Equity

Each hand EV calculation is done independently, so all hands that are +EV calls on their own are called and all hands that are -EV are folded. There is no such thing as “loss leader” type plays where one hand is played less profitably than it should for the sake of the whole strategy, “balance”, or protecting one’s range. Each hand is either profitable or it is not and should be

played accordingly.

The aggregate EV of BB's MES (calling all +EV hands and folding all -EV hands) weighted to each hand combinations frequency is 13.77 chips from a 15 chip pot, this being 92% of the pot *(Hand Range 19)*.

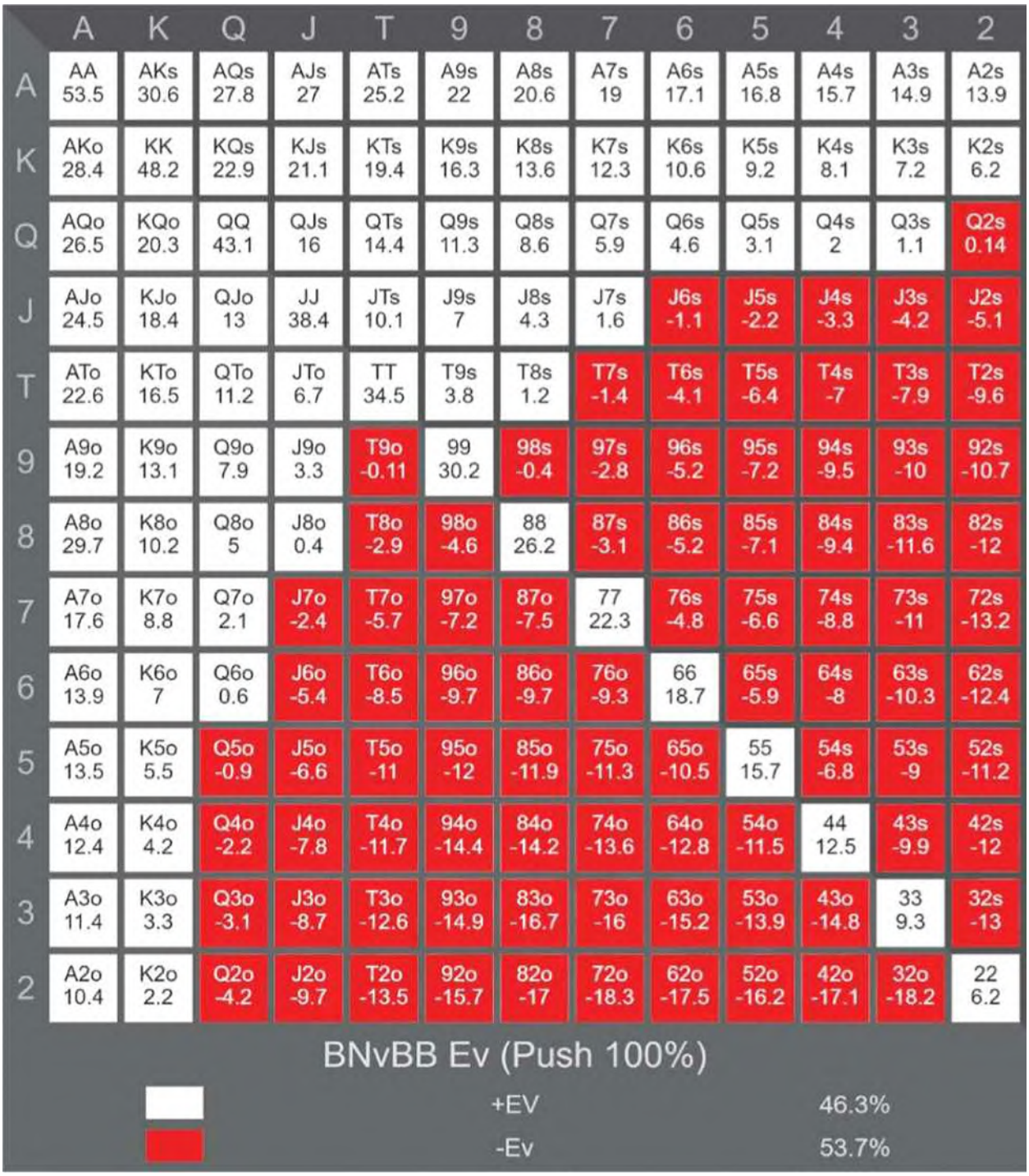


Hand Range 19: Calculating BB's MES

The aggregate EV of BN's *exploitative strategy* (moving all-in with 100% hands) is: 1.2228 chips from a 15 chip pot, this being 8% of the pot *(Hand Range 20)*.

Counter Exploitation

MES is calculated vs an opponent's fixed strategy, but an adaptive opponent can modify their strategy to a new strategy that is in turn maximally exploitative vs your own MES, improving their expectation.



Hand Range 20: Aggregate EV of BN's Exploitative Strategy

Example

Consider the previous example, where the BN played a strategy that consisted of simply going all-in with all hands for 10bb. The BB's MES was to call 66.21% hands and fold the other

33.79% of hands. If the BN knows the BB's calling strategy, they can adjust their pushing strategy to maximally exploit the BB.

We can find which BN hands are +EV shoves by applying our EV equation to each hand:

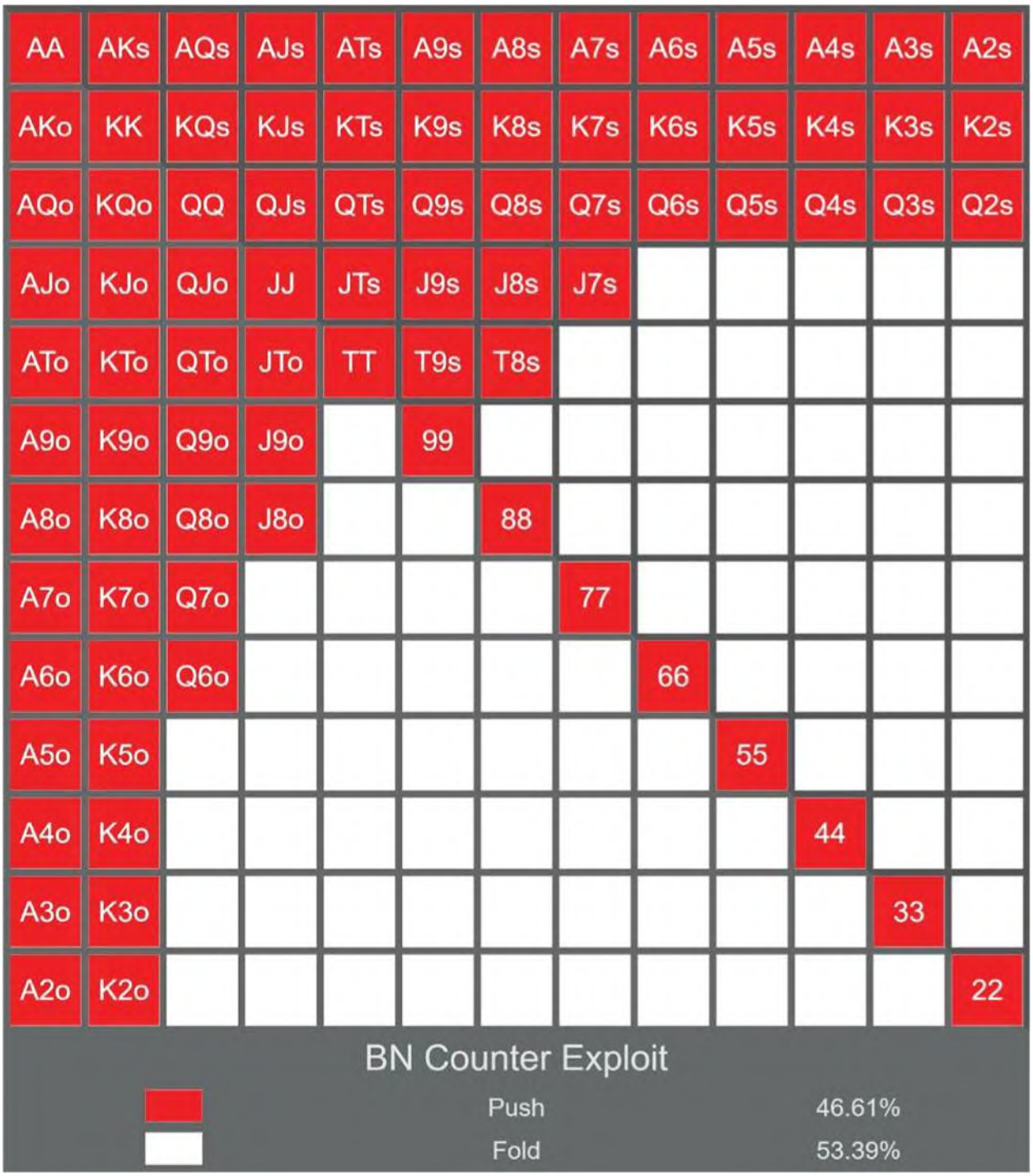
$$Ev\ [Shove] = [(Ev\ of\ Fold) * (\%\ BB\ Folds\ )] + [(Ev\ Called) * (\%\ BB\ Calls)]$$

Calculating all hands EV by hand can be very time consuming, so we can also use a push/fold app like Hold'em Resources Calculator (HRC) (holdemresources.net).

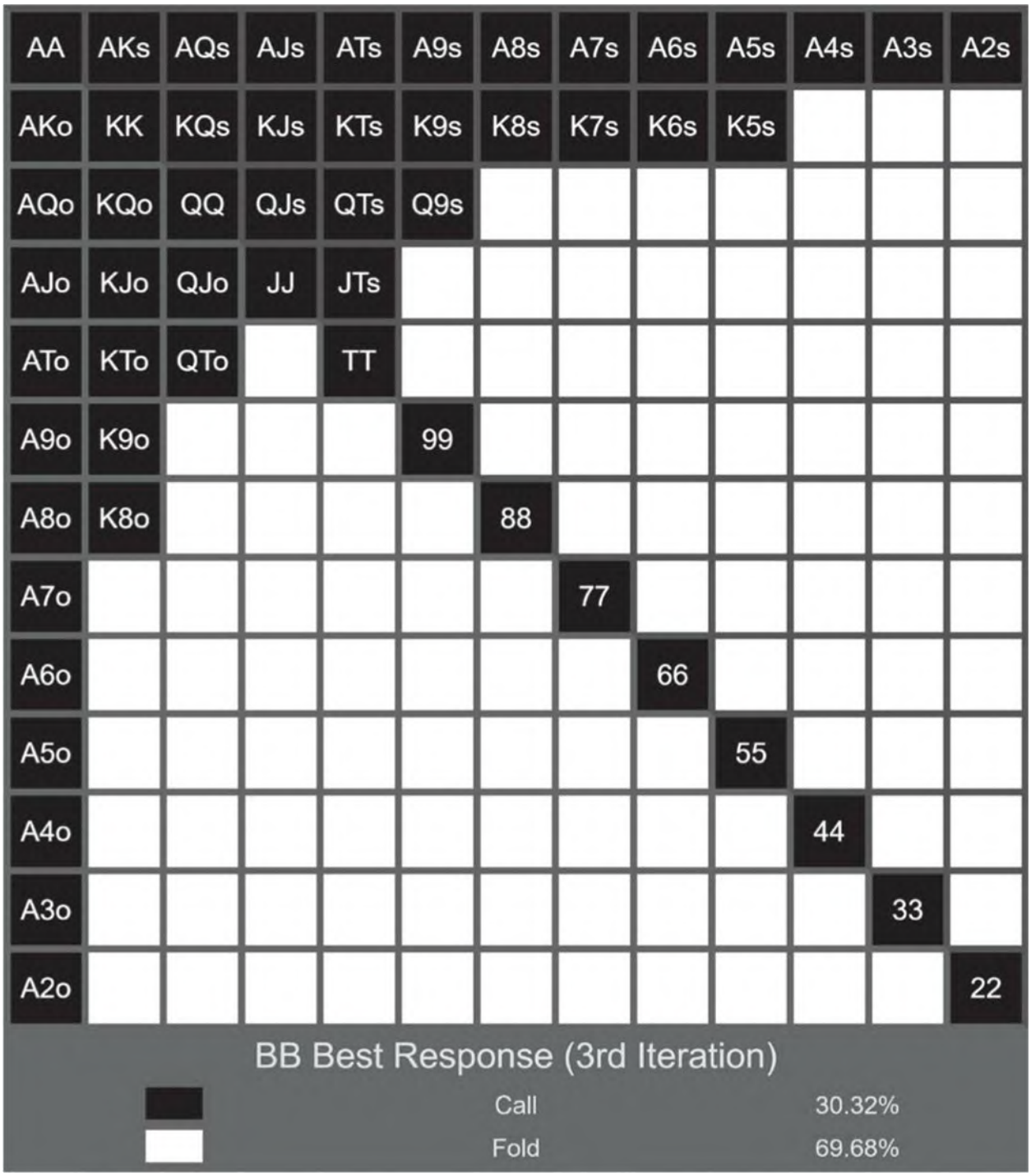
Second Iteration: BN counter exploit is to shove 46.61% of hands and fold 53.39% of hands *(Hand Range 21)*.

Next, the BB can also change strategy to find the best response vs the new BN strategy.

Third Iteration: BB best response is to call 30.3% of hands and fold 69.7% of hands *(Hand Range 22)*.



Hand Range 21: The BN Counter-exploit



Hand Range 22: BB Best Response

If this process of both players counter-adjusting continues for a large enough number of iterations, eventually the players will reach an equilibrium point where neither can improve upon the strategy they are already playing. At this point it can be said that both players are maximally exploiting each other. This situation is called Nash Equilibrium.

It may also occur that the players' strategies alternate back and forth and never converge to an equilibrium. In this case, the equilibrium can still be found by making slight changes in the players' response. Instead of switching all the way to the best response on each iteration, each player can adjust their strategy one step at the time in that direction.

The Nash Equilibrium

In the poker world, GTO (Game Theory Optimal) is often used as a synonym for Nash Equilibrium.

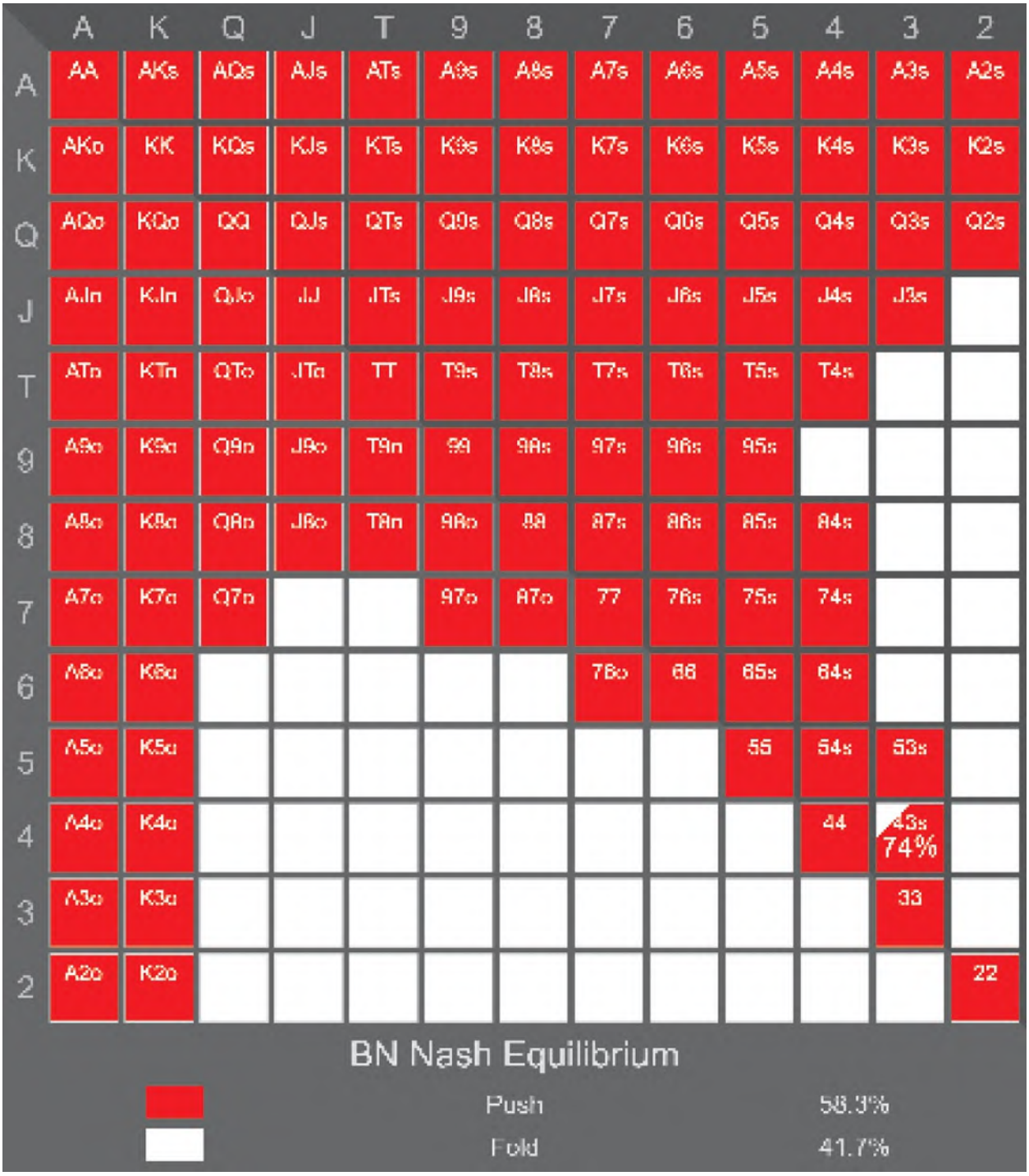
Nash Equilibrium is a set of strategies where:

- ♦ Players are clairvoyant: each player knows every other player's exact strategy.
- ♦ All players are maximally exploiting each other simultaneously.
- ♦ No player can unilaterally change their strategy to improve their own expectation.

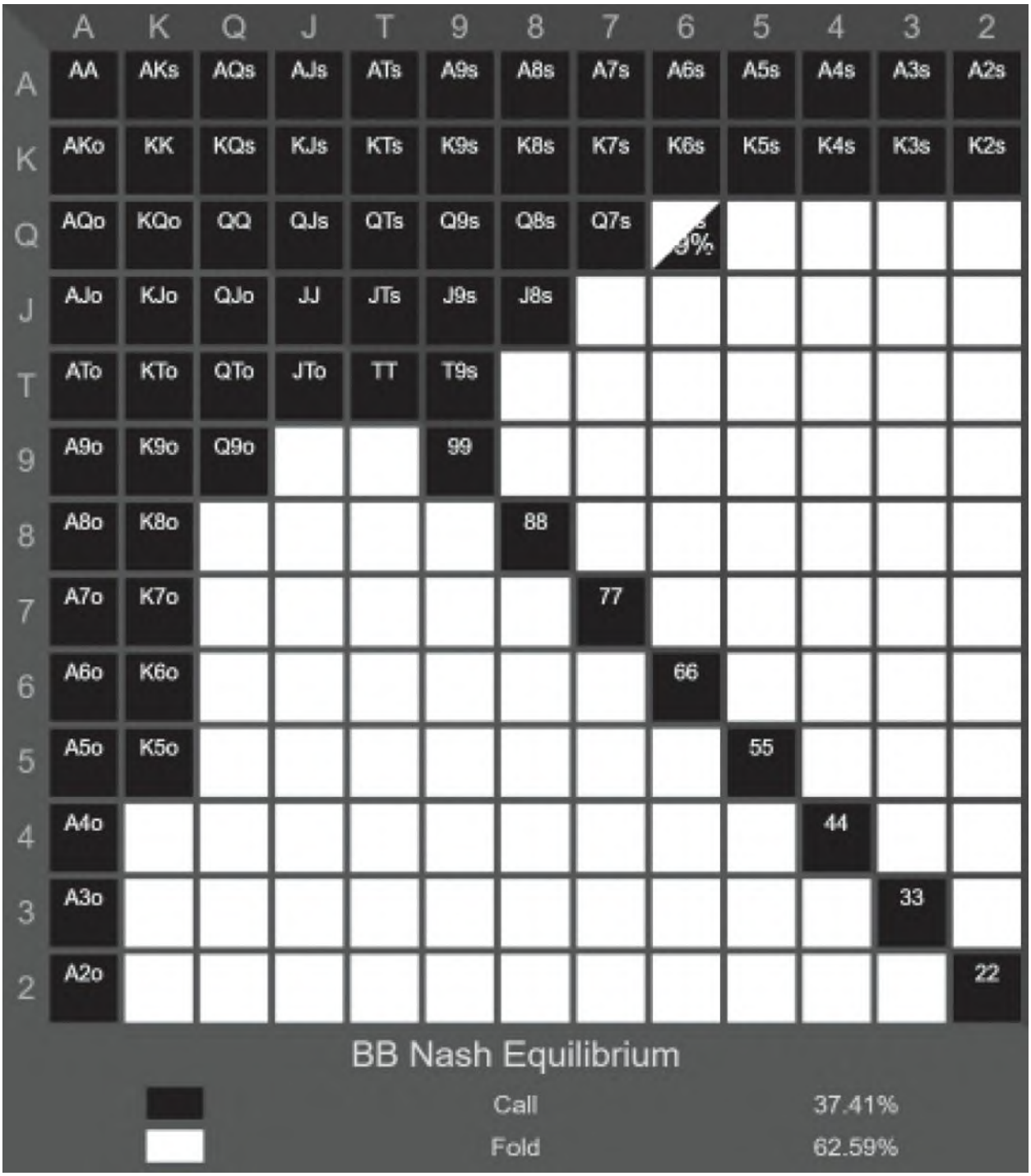
Equilibrium strategies are maximally exploitative when played vs an unexploitable opponent, so they inherit all the properties of MES, which are:

- ♦ Individual hands are always played in the most profitable way possible, and so GTO play never involves playing a hand less profitably than it should be played for the sake of balance.
- ♦ Strictly dominated strategies cannot be a part of a Nash Equilibrium, as it is irrational for any player to use them.
- ♦ The only way a hand can be played in more than one way at the equilibrium (mixed strategy) is if multiple strategic choices have the same EV.

The following are Nash Equilibrium solutions (generated with HRC) for the previous example when playing heads-up with 10bb stacks where pushing and folding are the only options *(Hand Ranges 23 and 24)*.



Hand Range 23: BN Nash Equilibrium



Hand Range 24: BB Nash Equilibrium

The value of the push/fold game for both players across the different iterations *(Table 9)*.

Player	Iteration 1 EV	Iteration 2 EV	Iteration 3 EV	Nash Equilibrium EV
BN	1.22	6.25	4.23	4.55
BB	13.77	8.48	10.75	10.45

Table 9: Iterations of the Push/Fold Game

In the push/fold example, if the BB knew that the BN was on the first iteration (where they would just push with 100% range), BB could improve their EV to 13.77 by applying the MES strategy of calling 66.21% of hands. But if the BB is wrong about the BN's play, or if the BN outthinks the BB and plays the second iteration strategy (push 46.61%) instead, then BB's EV would actually go down to 8.48. If the BB plays the GTO strategy of calling 37.4% vs a BN push, their EV is guaranteed to be 10.45, no matter what the BN does.

> *One of the main reasons Nash Equilibrium or GTO strategies are powerful is that they give you a guaranteed minimum EV. The way they are defined, they assume your opponent knows your strategy and that their strategy is the absolute best response to what you are doing. This is why GTO strategies are referred to as unexploitable. It is mathematically impossible for any opponent to gain an edge on you, meaning you will either break even or profit.*

Another advantage of playing the equilibrium strategy is that you don't have to try to trick your opponents by getting into crazy leveling wars. GTO strategies, by definition, don't make specific plays vs specific types of opponents. They assume your opponent will correctly adjust to whatever you do and thus they focus more on playing solid poker rather than constantly trying to get inside your opponents' heads.

If you play GTO against any opponent who is not perfectly countering your strategy (also playing GTO), your expectation will be greater than at equilibrium and will increase as your opponent's strategy gets worse. However, equilibrium strategies won't earn you as much EV as a strategy that is perfectly designed to counter the specific mistakes of your opponents. Top players develop sound baseline GTO strategies so they remain unexploitable vs tough or unknown opponents, but they also have the ability to take advantage of their opponent's leaks by making exploitative adjustments as they learn more about their opponent's play.

The Indifference Principle

The indifference principle was defined very accurately by Will Tipton in his excellent book

Expert Heads Up No Limit Hold'em, Volume 1: Optimal and Exploitative Strategies (D&B Publishing):

> *"Equilibrium strategies are, by definition, maximally exploitative strategies when facing an opponent who is playing his own GTO strategy – in this case, every hand is played as profitably as possible. So, the only way a hand can be played in two different ways at the equilibrium is if both of those actions have exactly the same EV; that is, if the player is indifferent to his choice of actions. This is known as the Indifference Principle: if a player plays a mixed strategy with a hand at the equilibrium, then it must be that all of the actions he takes with a nonzero frequency have the same EV. This is a powerful statement, because it tells us something about the GTO strategy of the player's opponent. If a player is indifferent between two options, it must be that his opponent is playing in such a way as to a make him so."*

This principle is intimately connected with the idea of balance. Think back to our previous example where we know that BN's GTO push range is 58.3% of hands. The reason they can't go all-in with a larger percentage of hands is because BB is calling enough so that the BN can't profit with the bottom of their pushing range (43s). If they could push and profit with the bottom of their range, the BN would just keep profitably adding hands to their pushing range. At the same time, if the BN was losing money pushing 43s, they would choose not to do so and another hand would become the new bottom of their range. So, the BB must call the exact amount that makes the worst hand in BN shoving range break even or, in other words, indifferent to pushing or folding. Since 43s is indifferent to pushing or folding, it is played with a mixed strategy: 74%-push, 26%-fold. If the BN pushes 43s more than 74%, BB could exploit by calling more hands, making 43s a -EV Push.

At the same time, in equilibrium, the BB can only profitably call 37.4% of hands. The bottom of their calling range, Q6s, is breaking even and is also played with a mixed strategy: call-39%, fold-61%. If the BB calls Q6s more than 61% of the time, the BN could exploit by jamming a little bit tighter, making Q6s a -EV Call.

The Clairvoyance Toy Game

Consider the following simplified poker situation:

Example

Two Players: P1 and P2
Pot: $100
Effective Stack: $100
Street: River
P1 Range: A♠A♥, Q♣Q♦
P2 Range: K♣K♦
Board: 3♠3♥3♣2♦2♠
P1: Out of Position
P2: In Position
Both players are clairvoyant: They both know each other's strategy.
What is the value of the game for each player?

In this set up, P1 has a polarized range. AA represents the nuts and QQ represents air because it cannot win at showdown against P2's condensed range of KK, which is a bluff-catcher.

What is each player's range vs range equity?

P1 wins the pot half the time when holding AA and loses half the time when holding QQ. Thus each player's equity in this pot is 50%.

If each player's equity is 50%, and the pot is $100, what is the player's EV?

Remember that equity alone does not account for post-flop play so, even if both players have 50% equity, that doesn't necessarily mean that they will capture 50% of the pot.

As we will see after solving this toy game, the EV of P1 is in fact $75 and the EV of P2 is only $25, even if both players play perfectly!

Eliminating Dominated Strategies

Fold AA vs a bet

AA always wins, so the EV of calling a bet of any size with AA is:

$$Ev\ Calling\ AA = Pot + Bet = \$100 + Bet$$

$$Ev\ Folding\ AA = 0$$

Folding the nuts is clearly a dominated strategy that should never be used.

Calling a Bet with QQ

$$Ev\ Folding\ QQ = 0$$

QQ can never win at showdown vs KK. So, the EV of calling a bet of any size with QQ is:

$$Ev\ Calling\ QQ = -Bet$$

Calling a bet with a hand that cannot win is a dominated strategy, thus P1 should always fold QQ to a bet of any size because calling loses whatever the bet amount is.

Betting or Raising KK

Since P1 never folds AA and never calls a bet with QQ, betting KK doesn't accomplish anything. Betting loses more money when P1 holds AA, thus betting KK is a dominated strategy that should never be used.

Checking with AA

We know that P2 never bets with KK, so if P1 checks AA, P2 will just check back and P1 will never win an extra bet, so P1 should always bet AA.

After eliminating all dominated strategies, the game can be reduced to the next set of questions:

- ♦ What is the optimal bet-size for P1?
- ♦ How often does P1 bluff with QQ?
- ♦ How often does P2 call with KK?
- ♦ What happens if player's positions are reversed?

P1's optimal bet-size is to go all-in. We will demonstrate this later but, for now, let's have P1's only bet-size to be all-in.

Ruling Out Pure Strategies

We know that P1 should always bet with AA, but what about QQ? Let's analyse.

Pure Strategy A: P1 Bluffs QQ All the Time

P2's EV when P1 always bluffs his QQ:

$$P2\ Ev\ [Bluff\ Catch] = [\%W * \$W] - [\%L * \$R]$$

$$P2\ Ev\ [Bluff\ Catch] = [0.5 * 200] - [0.5 * 100]$$

(P2 wins the pot half the time when P1 is bluffing and loses the pot half the time when P1 has AA)

$$P2\ Ev\ [Bluff\ Catch] = [100] - [50] = \$50$$

We already know that P2's EV in this game should be $25, so the P2 strategy of bluffing with QQ all of the time is suboptimal because it gives P2 a higher payoff ($50) than his real expectation ($25).

Pure Strategy B: P1 never bluffs QQ

If P1 never bluffs with QQ, P2 has no reason to ever call with KK because he would always lose.

In that case, P1 would bet his AA and never get called, and whenever he has QQ, the hand will get checked down and P2's KK will win at showdown. With this strategy, P2's EV is:

$$P2\ Ev\ [Check\ Down] = 0.5 * \$100 = \$50$$

Again, this line offers P2 a higher payoff than his real expectation.

Player1 Solution

We know that P2 will never bet KK, so the only way P1 can get value with AA is by betting, but if P1 never bluffs with QQ, calling with KK would be -EV, meaning P2 should always fold. If P1 always bluffs with QQ, P2's call with KK would be +EV, meaning he should always call.

We need to find P1's optimal bluffing frequency so that P2 doesn't make money calling with KK but, at the same time, doesn't lose money. In other words, P1 needs to make P2 *indifferent* to calling or folding:

$$P2\ Ev\ [Call] = P2\ Ev\ [Fold]$$

By definition we know that the EV of folding is 0 so,

$$P2Ev[Call] = 0$$

Using our EV equation:

$$Ev = [\%W * \$W] - [\%L * \$R]$$

For clarity let's substitute:

%W = W

%L = 1 – W

$W = b + p

$R = b

$$[W * (b + p)] - [(1 - W) * b] = 0$$

Where:

b = bet and p = pot

$$[Wb + Wp] - [b - Wb] = 0$$

$$Wb + Wp - b + Wb = 0$$

$$2Wb + Wp = b$$

$$W(2b + p) = b$$

$$W = \frac{b}{(2b + p)}$$

To be indifferent between calling or folding, P2 has to win with a frequency of:

$$\frac{b}{(2b + p)} = \frac{100}{300} = \frac{1}{3} = 33.3\%$$

This is the exact same number as his pot odds:

$$Pot\ Odds\ [Call\ KK] = \frac{Risk}{Risk + Reward}$$

$$Pot\ Odds\ [Call\ KK] = \frac{100}{(100 + 200)} = \frac{1}{3} = 33.3\%$$

This result shouldn't be surprising, as P2 wins the pot with the same frequency as P1 bluffs. We know that on the river, with no more cards to come, the pot odds simply tell a player how often a call has to be good for it to break even. *So, to make P2 indifferent between calling or folding, P1 must bluff with a frequency equal to P2 pot odds.*

Now all we need is to do is figure out how often P1 has to bet is QQ so that their betting range is *67% Value* and *33% Bluffs*.

Player1 Bluff Frequency

$$Bluff\ \% = \frac{b}{(2b + p)}$$

Player1 Value Frequency

$$Value\ \% = 1 - (Bluff\ \%)$$

$$Value\ \% = 1 - \left(\frac{b}{2b + p}\right)$$

$$Value\ \% = 1 - \left(\frac{2b + p - b}{2b + p}\right)$$

$$Value\ \% = \frac{b + p}{2b + p}$$

Player1 Bluff-to-Value Ratio

$$Bluff\ to\ Value\ Ratio = \frac{Bluff\ \%}{Value\ \%}$$

$$Bluff\ to\ Value\ Ratio = \frac{\frac{b}{(2b+p)}}{\left(\frac{b+p}{2b+p}\right)}$$

$$Bluff\ to\ Value\ Ratio = \frac{b}{b+p}$$

$$Bluff\ to\ Value\ Ratio = \frac{100}{100+100} = \frac{1}{2} = 50\%$$

Player1 needs to have 1 bluff for every 2 value combos in their betting range, so should bet his QQ at a frequency of: 1/2 or 50%.

Player1 Total Frequencies

P1 has AA half the time and bets them 100% of the time:

$$0.5 * 100\% = 50\%$$

P1 has QQ half the time and bets them 50% of the time:

$$0.5 * 0.5\% = 0.25\%$$

$$Total\ Betting\ Frequency = AA\% + QQ\% = 50\% + 25\% = 75\%$$

$$Total\ Checking\ Frequency = 100\% - 75\% = 25\%$$

Player1 Final EV Numbers

AA EV:

$$AA\ Ev\ [Bet] = [(Ev\ of\ Fold) * (\%\ P2\ Folds\ )] + [(Ev\ Called) * (\%\ P2\ Calls)]$$

$$AAEv[Bet] = [(100) * (0.5)] + [(200) * (0.5)]$$

$$AAEv[Bet] = 50 + 100$$

$$AAEv[Bet] = \$150$$

$$AAEv[Check] = [Pot * (Equity\ )]$$

$$AAEv[Check] = [100 * (100\%)] = \$100$$

(The EV of betting AA is $150; this is clearly higher than the EV of checking AA, which is $100)

$$AA\ [Ev] = [AA\ Ev\ [Bet] * AA\ Bet\ \%] + AA\ Ev\ [Check] * AA\ Check\%]$$

$$AA\ [Ev] = [150 * 100\%] + [100 * 0\%]$$

$$AA[Ev] = \$150$$

QQ EV:

$$Ev\ [Bet\ QQ] = [(100) * (0.5\ )] + [(-100) * (0.5)]$$

$$QQ\ Ev\ [Bet] = 50 - 50$$

$$QQ\ Ev\ [Bet] = 0$$

$$QQ\ [Ev] = [QQ\ Ev\ [Bet] * QQ\ Bet\ \%] + [QQ\ Ev\ [Check] * QQ\ Check\ \%]$$

$$QQ\ [Ev] = 0 * QQ\ Bet\ \% + 0 * QQ\ Check\ \% = 0$$

Then the value of the game for P1 is:

$$P1\ Ev = AA\ [Ev] * AA\% + QQ\ [Ev] * QQ\%$$

$$P1\ Ev = \$150 * 50\% + 0[Ev] * 50\% = \mathbf{\$75}$$

Player2 Solution

We know that P1 always bets with AA, so when they check, they are giving up with QQ. This means that when P2 sees P1 check, he should check back and win at showdown with KK because there is no value in betting, as P1 will always fold QQ. To solve the game for P2, all we need to do is find his strategy and EV when P1 bets.

If P1 is betting a balanced strategy by bluffing 1/3 of the time (bet AA 100% and QQ 50%)

P2's calling EV is:

$$P2\ Ev\ [Call] = [\%W * \$W] - [\%L * \$R]$$

$$P2\ Ev\ [Call] = \left[\frac{1}{3} * 200\right] - \left[\frac{2}{3} * 100\right]$$

$$P2\ Ev\ [Call] = \left[\frac{200}{3}\right] - \left[\frac{200}{3}\right]$$

$$P2\ Ev\ [Call] = 0$$

If P1 plays their equilibrium strategy, it doesn't matter if P2 calls or folds because the EV of both actions is 0. That said, P2 still needs to call at some frequency, otherwise P1 could deviate from the equilibrium to exploit them by bluffing more often.

For example, if P2 chooses to never call with KK, P1 could start bluffing with QQ 100% of the time and win the entire pot. If P2 chooses to always call with KK, then P1 could exploit P2

by no longer bluffing QQ.

We need to find P2's optimal calling frequency so P1 doesn't make money when bluffing with QQ but doesn't lose money either. In other words, P2 has to make P1 indifferent to bluffing or checking with QQ.

$$P1\ Ev\ [Bluff] = P1\ Ev\ [Check]$$

We know that P1's EV of checking QQ is 0 because he will lose at showdown, so:

$$P1\ Ev\ [Bluff] = 0$$

Using our EV formula:

$$[(Ev\ of\ Fold) * (\%\ P2\ Folds\ )] + [(Ev\ Called) * (\%\ P2\ Calls)] = 0$$

For clarity let's substitute:
%P2calls = c
%P2folds = 1 – c
EV on fold = p
EV called = –b

$$[p * (1 - c)] + [\ -b * (c)] = 0$$

Where:
b = bet
p = pot

$$(p - pc) - bc = 0$$

$$p - pc - bc = 0$$

$$pc + bc = p$$

$$c(b + p) = p$$

$$c = \frac{p}{(b + p)}$$

This number is known as *Minimum Defense Frequency (MDF)*.

$$MDF = \frac{p}{(p + b)}$$

$$MDF = \frac{100}{(100 + 100)} = \frac{1}{2} = 0.5$$

P2 has to call 50% of the time with KK to make P1 indifferent to bluffing or checking with QQ. Another way to solve this problem is by asking how often P2 has to fold to make P1 indifferent. We can do this by using our EV formula.

$$[(Ev\ of\ Fold) * (\%\ P2\ Folds\ )] + [(Ev\ Called) * (\%\ P2\ Calls)] = 0$$

For clarity let's substitute:
%P2calls = 1 – f

%P2folds = f
EV on fold = p
EV called = –b

$$[(p) * (f)] + [(-b) * (1 - f)] = 0$$

$$pf - b + bf = 0$$

$$pf + bf = b$$

$$f(b + p) = b$$

$$f = \frac{b}{(b + p)}$$

$$f = \frac{100}{(100 + 100)} = \frac{1}{2} = 0.5$$

P2 has to fold KK 50% of the time to make P1 indifferent to bluffing or checking with QQ. Notice that this result, b/(b + p), is the same as P1's bluff-to-value ratio.

This number is also known as Alpha. It represents how often a bluff has to work for it to break even. In this case if P1's bluff with QQ works more than 50% of the time, the bluff would be profitable.

$$Alpha = \frac{b}{b + p}$$

Since folding frequency and calling frequency are complementary numbers, they should add up to 1. So, *if you know one, you can always easily calculate the other*.

P1's minimum defense frequency can also be calculated as:

$$MDF = 1 - Alpha$$

$$MDF = 1 - \frac{b}{b + p}$$

$$MDF = \frac{(b + p) - b}{b + p}$$

$$MDF = \frac{p}{(p + b)}$$

These two results: *Alpha* and *MDF* are key GTO concepts and will be revisited throughout this book.

Player2 Final EV Numbers

$$P2\ Ev\ [Call] = 0$$

$$P2\ Ev\ [Fold] = 0$$

$$P2\ Ev\ [Check] = Pot * P2\ EQ$$

Since KK always beats QQ at showdown: P2 EQ vs QQ is 100%

$$P2\ Ev\ [Check] = 100 * 100\%$$

$$P2\ Ev\ [Check] = \$100$$

P1 only checks his QQ 50% of the time, so

$$P2\ Ev\ [Check] = \$100 * 25\% = \$25$$

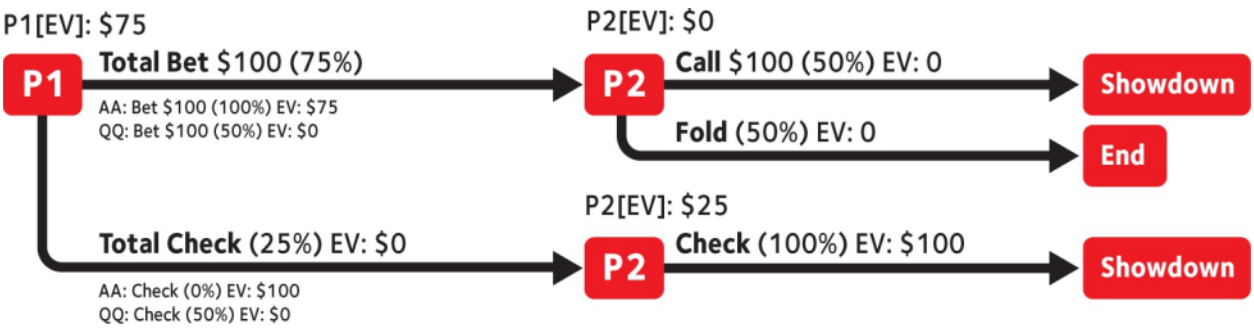
Full Toy Game Solution Summary

Pot: $100
Stack Depth: $100
Board: 3♠3♥3♣ 2♦ 2♠

Player1: EV $75
AA: Bet $100 (100%), Check (0%)
QQ: Bet $100 (50%), Check (50%)
P1 Total Betting Frequency: 75%
P1 Total Checking Frequency: 25%

Player2: EV: $25
Vs Check: Check KK (100%)
Vs $100 Bet: Call KK (50%), Fold KK (50%)

Decision Tree (at Equilibrium)



We still have two more questions to answer for a complete solution.

What Happens if the Players' Positions are Reversed?

In a nuts/air vs bluff catcher situation, position doesn't matter! If P2 is OOP instead, they still won't ever bet with KK because that is a dominated strategy, and so P2's equilibrium strategy would be to check 100% to P1.

In position, P1 still wants to bet AA 100% of the time because checking back is a dominated strategy, and P1 still wants to bluff with QQ at a frequency of b/(b + p).

What is the Optimal Bet-sizing for Player1?

On the river, if P1's range is perfectly polar and P2's Range is condensed, P1's optimal bet-size is always all-in! As we can see in *Table 10*, P1's EV increases as the bet-size increases. This is because the bigger the bet-size, the more often P1 can bluff. In this game, P2 only makes money from the tree branch where P1 checks with QQ, so the less often that branch happens, the less money P2 will make. Therefore, P1's EV is maximized when betting as large as possible. If P1 could bet an infinite amount of money, it would result in the capture of 100% of the pot.

Bet size	EV	Total Bet Frequency	Check Frequency
10	$ 54.6	54.60%	45.40%
25	$ 60.0	60.00%	40.00%
50	$ 66.7	66.67%	33.33%
75	$ 71.4	71.40%	28.60%
100	$ 75.0	75.00%	25.00%
125	$ 77.8	77.77%	22.23%
150	$ 80.0	80.00%	20.00%
200	$ 83.5	83.50%	16.50%
250	$ 85.7	85.70%	14.30%
300	$ 87.5	87.50%	12.50%
500	$ 91.6	91.60%	8.40%
1,000	$ 95.4	95.40%	4.60%
10,000	$ 99.4	99.40%	0.60%

Table 10: P1's EV by Bet Size

Minimum Defense Frequency (MDF)

As seen in the Clairvoyance Toy Game, MDF is related to the alpha number:

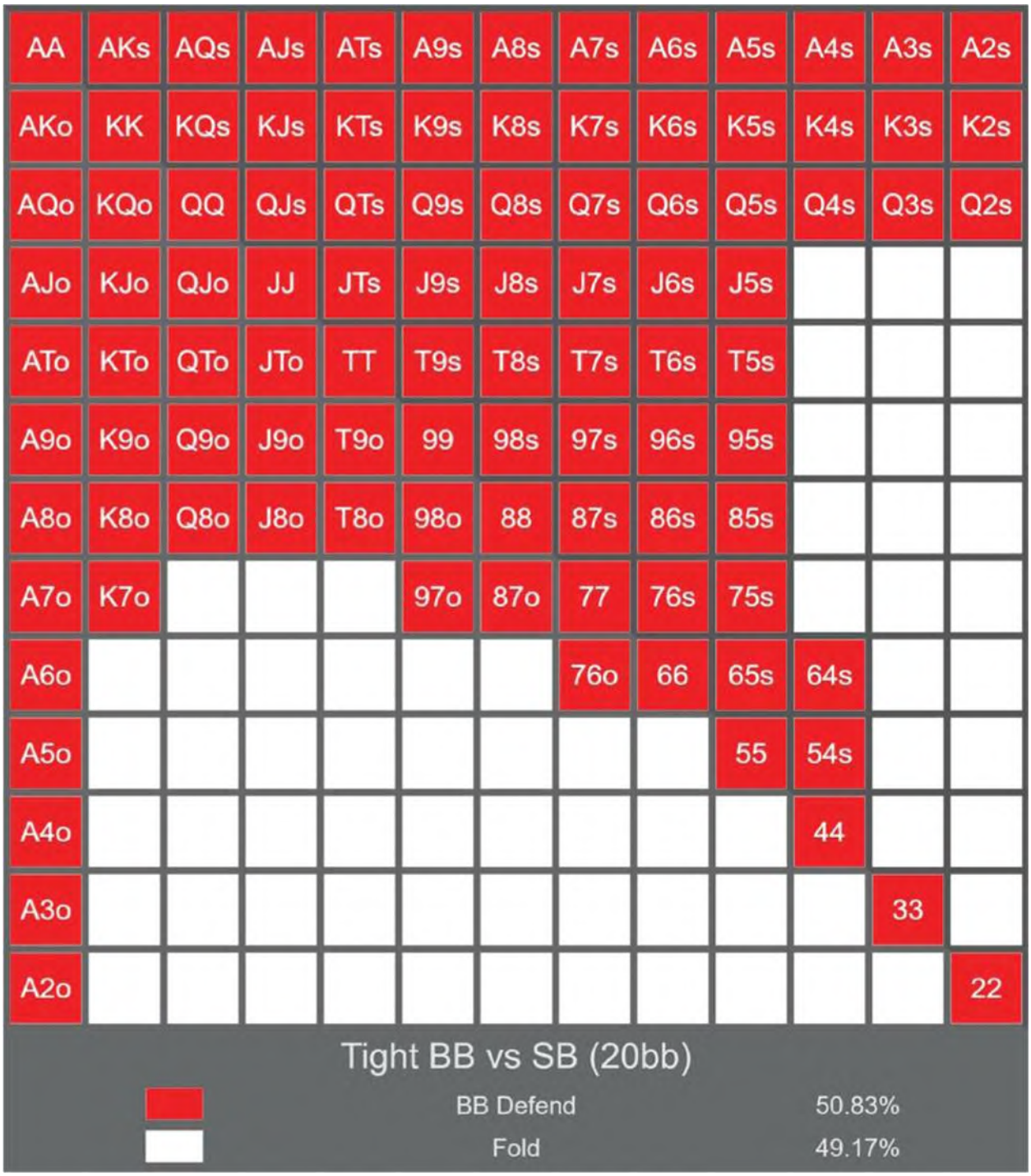
$$Alpha = \frac{b}{b + p}$$

$$MDF = 1 - Alpha$$

The Alpha number is particularly useful when bluffing because it tells you how often a bluff with 0% equity has to work for us to break even.

Example
Game: Live Multi-table Tournament
Stacks: SB=50bb, BB=20bb
Players: 9 (12.5% ante)
Pre-flop: (2.625bb) Hero is in the SB with 72o and the action gets folded to him, the BB is a very tight and straightforward player who doesn't fight enough for small pots.

72o is a hand that would normally be folded from the SB vs a strong opponent, but here Hero thinks BB is only defending ~50.8% hands vs a SB steal *(Hand Range 25)*. You have to determine if you can profitably attempt to steal the blinds with your weak hand.



Hand Range 25: A Tight Defending Range from the BB

We can use the Alpha equation to find out how often the bet has to work to break even if we raise 2.5bb from the SB:

$$Alpha = \frac{b}{b + p}$$

$$Alpha = \frac{2}{2 + 2.625}$$

$$Alpha = \frac{2}{4.625} = 0.43$$

If the bet works more than 43% of the time it will show an immediate profit, and in this case the BB is folding 49.17%.

You always fold 72o vs a 3-bet, and let's also assume you always lose the pot when the BB calls, which is not true because when called you will still have some equity vs the calling range (but it is worth looking at the worst-case scenario because, if you can profit then, you will always profit).

$$Ev = [(Ev\ on\ Fold) * (\%\ BB\ Folds\ )] + [(Ev\ called) * (\%\ BB\ Calls)] + [(Ev\ Reraised) * (\%\ BB\ Raises)]$$

$$Ev = [(2.625) * (0.4917\ )] + [-2 * (\%\ BB\ Calls)] + [-2 * (\%\ BB\ Raises)]$$

$$Ev = [(2.625) * (0.4917\ )] + [-2 * (\%\ BB\ Calls)] + [-2 * (\%\ BB\ Raises)]$$

$$Ev = [1.291] - 2 * [\%\ BB\ Calls + \%BB\ 3bets)$$

$$Ev = [1.291] - 2 * [\%\ BB\ Defends)$$

$$Ev = [1.291] - 2 * [0.5083)$$

$$Ev = 1.291 - 1.017$$

$$Ev = 0.274bb$$

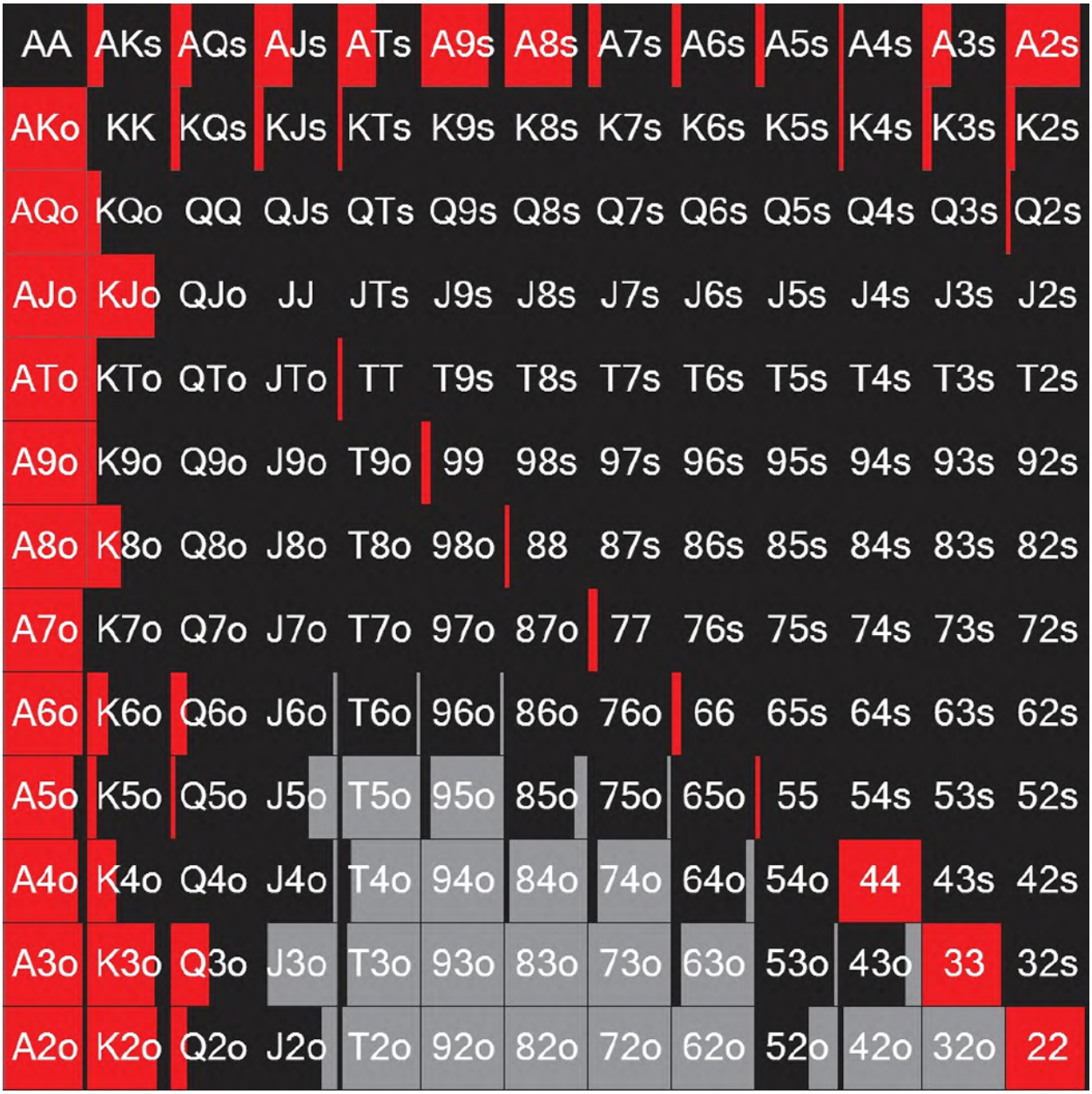
$$Ev = 27.4bb/100$$

The steal with 72o yields a profit of 27.4bb/100. This raise is only profitable because Villain defends the big blind way too tightly, allowing you to exploit by stealing their blind with any two cards (ATC).

From the BB's perspective the defence should be at a frequency of:

$$MDF = 1 - Alpha = 1 - 0.43 = 0.57$$

The BB's minimum defense frequency is 57% hands, but the BB's GTO solution in this spot is to defend **82.1% hands** *(Hand Range 26)* which, for many players, sounds crazy. Later in the book we will study BB defense strategies in depth and understand why this is possible.



Hand Range 26: BB vs SB (2.5x Raise) 20bb GTO Defense
• 3-bet all-in: 17.9% / • Call: 54.3% / • Fold: 17.9%

Multiway

The Alpha number tells you how often a bet with a 0% equity hand needs to work for you to break even. However, if there are several opponents still active after the bet, you need to make a small adjustment to the formula to find out how often you need each Villain to fold individually to your bet. You do this as follows.

$$Average\ Fold\ Frequency = \sqrt[Opponents]{Alpha}$$

Where opponents are the remaining players to act after you.

Example
Game: Online Cash Game
Stacks: BB=99bb, SB=220bb, BN=114bb
Blinds: $1/$2
Players: 6 (no ante)
Pre-flop: (1.5bb) The action gets folded to Hero on the BN. How often do each one of the players in the blinds fold to a 2.5bb raise for Hero to have a profitable open with any two cards (ATC)?

We can start by calculating Alpha:

$$Alpha = \frac{b}{b + p}$$

$$Alpha = \frac{2.5}{2.5 + 1.5}$$

$$Alpha = \frac{2.5}{4} = 0.625$$

In total, Hero needs the raise to work 62.5% of the time to break even. To find out how often each Villain should fold individually, all you need to do is calculate the square root of Alpha:

$$Average\ Fold\ Frequency = \sqrt[2]{0.625}$$

$$Average\ Fold\ Frequency = 0.79$$

So, if each Villain folds more than 79% of the time to a BN steal, Hero has a profitable raise with ATC.

Alpha vs one player is given by

$$\sqrt[1]{Alpha} = Alpha$$

For three players you calculate:

$$\sqrt[3]{Alpha}$$

and for four:

$$\sqrt[4]{Alpha}$$

etc.

Each player's minimum defense frequency can be calculated as:

$$Individual\ MDF = 1 - \sqrt[Opponents]{Alpha}$$

In this example, each player should defend at least (1 – 0.79) = 21% of the time to stop Hero from automatically profiting by raising ATC on the BN.

Let's consider a small adjustment to this example. Suppose Hero looks at the HUD (heads-up display) and the statistics on the Villains are:

$$BB\ [Fold\ vs\ BN\ Steal] = 69\%$$

$$SB\ [Fold\ vs\ BN\ Steal] = 87\%$$

Can Hero profit by raising ATC on the BN vs these two Villains?

In this case you already know each Villain's individual fold vs a BN steal frequency. If each player was folding at least 79%, solving this example would be trivial since both players would be folding frequently enough.

How can you know if Hero can profit by raising ATC on the BN vs these two Villains?

You can solve this by finding the combined fold to steal frequency of both players:

$$BB\ \&\ SB\ [Fold\ to\ BN\ Steal] = BB\ [Fold\ vs\ BN] * SB[\ Fold\ vs\ BN]$$

$$BB\ \&\ SB\ [Fold\ to\ BN\ Steal] = 0.69 * 0.87 = 0.60$$

Combined, these two players are folding 60% of the time and Alpha is 62.5%, so even though both players fold to BN steal is very high, Hero doesn't have a profitable BN steal with ATC (assuming Hero has 0% equity when called).

If you know each player's individual folding frequency, you can calculate their *combined folding frequency* by multiplying them together.

Assuming your bluffs have no equity, this formula works for any number of opponents and even for post-flop situations such as when discussing continuation bets.

Exploitative Play vs GTO

There are two possible types of exploitation: passive and active. Active exploitation further breaks down into maximal and minimal.

Passive Exploitation

Does GTO Play Make Money vs Bad Players?

It should be clear by now that in a heads-up situation, if one player is playing optimally vs a

suboptimal opponent then any deviation the weaker player makes away from GTO to a worse strategy can never increase their value, but it can cost them value, which will in turn be gained by the GTO player. This phenomenon is called *passive exploitation* because the optimal player does not have to do anything besides play an equilibrium strategy to gain EV from the suboptimal player. In a sense the weaker player is self-exploiting by playing poorly.

Active Exploitation

Active exploitation happens whenever a player deviates from their core strategy to further take advantage of an opponent's leak.

- A player who always plays Equilibrium Strategy is called a *GTO player*.
- A player who employs a *Maximally Exploitative Strategy* is called a *Maximally Exploitative Player*.
- A player who employs a *Minimally Exploitative Strategy* is called a *Minimally Exploitative Player*.

In general, when players talk about an exploitative player they are referring to a maximally exploitative player.

Maximally Exploitative Strategy (MES)

As explained earlier, MES happens when a player chooses to deviate from equilibrium to a strategy that maximizes EV vs a Villain's suboptimal strategy (obviously, this is only possible if the Villain isn't playing GTO). Consider the following simplified poker situation:

Example
Game: Heads-Up Sit N' Go *(Players can only push or fold)*
Effective Stack: 15bb
Blinds: 0.5bb/1bb
Pre-flop: Hero is in the SB. His GTO strategy is to push 45.7% of hands.

Let's imagine eight different types of Villain that Hero might encounter in a heads-up match:

♦ **GTO Player:** This player will call a 15bb SB push optimally with a 28.5% range.

♦ **10% Loose Player:** This type of Villain is a bit sticky and calls a 15bb SB push with a 31.4% range.

♦ **25% Loose Player:** This type of Villain is a bit stickier and calls a 15bb SB push with a 35.6% range.

♦ **100% Loose Player:** This type of Villain really hates folding and calls a 15bb SB push with a 57% range.

♦ **10% Tight Player:** This type of Villain is a tighter and calls a 15bb SB push with a 25.7% range.

♦ **25% Tight Player:** This type of Villain is a lot tighter and calls a 15bb SB push with a 21.4% range.

♦ **50% Tight Player:** This type of Villain is a massive nit and calls a 15bb SB push with a 14.3% range.

In *Table 11*, we summarize the SB EV gains of playing GTO and MES vs the various opponents, as well as Hero's potential EV loss if Villain plays GTO, instead of the suboptimal strategy, or counter-exploits Hero.

Ev in bb/100			Hero EV Gains vs Suboptimal Opponents		MES Net Gain Com-pared to GTO	Hero Potential EV Loss	
Villain Type	BB Calls Versus SB Push	SB Push (MES)	GTO	MES		Versus GTO	Versus Counter
GTO Player	28.50%	45.70%	0	0	0	0	0
10% Loose	31.40%	37.60%	0.5	1	0.5	-0.5	-1.8
25% Loose	35.60%	35.10%	2	4	2	-1	-3.2
100% Loose	57.00%	37.90%	21.1	27.4	6.3	-1.3	-2.5
10% Tight	25.70%	55.40%	0.1	0.5	0.4	-0.6	-1.7
25% Tight	21.40%	80.10%	1	5.6	4.6	-6.6	-22.1
50% Tight	14.30%	100.00%	4.8	29.4	24.6	-16.9	-62.4
				Average	6.4	-4.48	-15.62

Table 11: EV Gains and Loses Versus Different Villain Types

As seen in Table 11, GTO play can't lose or win EV vs a GTO player, but it gains EV vs suboptimal players depending on the severity of their leaks. MES on average gains 6.4bb/100 more than GTO vs suboptimal players but doing so creates a leak that can, on average, be counter-exploited for -15.62 bb/100.

Even vs an extremely bad opponent who is calling 2x more often than they should, MES only captures 6.3bb/100 more than GTO and can be exploited back for -2.5bb/100. If the Villain is calling 50% tighter than they should, MES does very well, yielding 24.6bb/100 more than GTO, but can in turn be counter-exploited by -62.4bb/100. Additionally, the strategy shift is extreme as Hero is now shoving 100% hands instead of 28%, so this exploitative adjustment can easily be spotted by an observant Villain.

MES involves a degree of risk, because you are putting yourself in a situation where your opponent could counter-exploit your new strategy to an even greater margin than you were trying to exploit them in the first place, if they figure out what you are doing. Also, if you are wrong with your assessment of Villain's play (which is inevitable from time to time) and adjust incorrectly, you will be the one deviating to a weaker strategy that will in turn lose value. Thus you must be very careful and have a high degree of certainty in your reads if you are aiming for maximum exploitation.

Minimally Exploitative Strategy (MinES)

Let's return to the Clairvoyance Toy game solution.

Pot: $100
Stacks: $100
Board: 3♠3♥3♣2♦2♠

Player1: EV $75
AA: Bet $100 (100%), Check (0%)
QQ: Bet $100 (50%), Check (50%)

Player2: EV $25
Vs Check: Check KK (100%)
Vs $100 Bet: Call KK (50%), Fold KK (50%)

Imagine a variation of this game where Hero is Player1 and Player2 is a Villain who tends to call slightly loose. Instead of calling 50% with KK, they call 55%.

If Hero keeps playing GTO strategy, he will not earn any extra EV vs this leak.

AA EV:

$$AA\ Ev\ [Bet] = [(Ev\ of\ Fold) * (\%\ P2\ Folds\ )] + [(Ev\ Called) * (\%\ P2\ Calls)]$$

$$AA\ Ev\ [Bet] = [(100) * (0.45)] + [(200) * (0.55)]$$

$$AAEv[Bet] = 45 + 110$$

$$AAEv[Bet] = \$155$$

$$AA\ [Ev] = [AA\ Ev\ [Bet] * AA\ Bet\ \%] + [AA\ Ev\ [Check] * AA\ Check\%]$$

$$AA\ [Ev] = [155 * 100\%] + [100 * 0\%]$$

$$AA\ [Ev] = \$155$$

QQ EV:

$$Ev\ QQ\ [Bet] = [(100) * (0.45\ )] + [(-100) * (0.55)]$$

$$Ev\ QQ\ [Bet] = [45] + [-55]$$

$$Ev\ QQ\ [Bet] = -10$$

$$QQ\ [Ev] = [Ev\ QQ\ [Bet] * QQ\ Bet\ \%] + [QQ\ Ev\ [Check] * QQ\ Check\ \%]$$

$$QQ\ [Ev] = -10 * 50\% + 0 * QQ\ Check\ \%$$

$$QQ\ [Ev] = -5$$

Then, the value of the game for P1 is:

$$P1\ Ev = [AA\ [Ev] * AA\%] + [QQ\ [Ev] * QQ\%]$$

$$P1\ Ev = [155 * 50\%] - [5 * 50\%]$$

$$P1\ Ev = 50\% * [155 - 5]$$

$$P1\ Ev = \$75$$

This is the same EV as seen previously.

If Hero implements the maximally exploitative strategy vs this Villain, he should bluff 0% of the time. If he only value-bets, his EV would be:

$$AA\ Ev\ [Bet] = [(Ev\ on\ Fold) * (\%\ P2\ Folds\ )] + [(Ev\ Called) * (\%\ P2\ Calls)]$$

$$AA\ Ev\ [Bet] = [(100) * (0.45)] + [(200) * (0.55)]$$

$$AA\ Ev\ [Bet] = 45 + 110$$

$$AA\ Ev\ [Bet] = \$155$$

And he never bluffs with QQ, so:

$$Ev\ [QQ] = 0$$

$$P1\ Ev = [AA\ [Ev] * AA\%] + [QQ\ [Ev] * QQ\%]$$

$$P1\ Ev = [155 * 0.5] + [-5 * 0]$$

$$P1\ [Ev] = \$77.5$$

The MES yields $2.5 per hand more than GTO and so, in theory, Hero should just keep pounding on Villain. However, from Villain's perspective, he has seen Hero bet the river only 50% of the time instead of 75% and, every time he calls, he gets shown AA. Hero's assumption is that Villain is calling slightly looser than he should, not that he is stupid. Even if he is very

slow to catch on, there is no reason to think he won't adapt as soon as he realizes that Hero is never bluffing.

If Villain counter-exploits Hero by switching to a strategy of always folding to his all-in, his EV becomes:

$$P2\ [EV] = P2\ Ev\ [Call] * Call\ \% + P2\ Ev\ [Check\ Down] * Check\ Down\ \%$$

$$P2\ [EV] = 0 * 0\% + 100 * 50\%$$

$$P2\ [EV] = \$50$$

This is 2x more than equilibrium per hand and 10x the amount Hero was exploiting the Villain for! So, Hero should be able to exploit Villain at least 10 times in a row before he catches on to Hero's strategy and adjusts, otherwise Hero will lose money. If Villain counter-exploits Hero even 2 out of 10 times, Hero would still lose $30, or -$3/hand, compared to GTO. If the Villain was particularly slow catching on and allows Hero to keep exploiting him for 45 hands in a row, and only adjusts for the final 5 hands, then Hero's EV over 50 hands would be -$12.5 compared to simply playing GTO.

$$50\ Hands\ [Ev] = [2.5 * 45] - [25 * 5]$$

$$50\ Hands\ [Ev] = [112.5] - [125]$$

$$50\ Hands\ [Ev] = -\$12.5$$

Unless your opponent is completely oblivious to your play, you can't expect them to ignore your betting frequency when you are obviously playing MES and being completely unbalanced. Assuming they are intelligent and capable of adjusting to your play, how do you take advantage of their leak in a way that doesn't leave you open to massive counter-exploitation?

You can build their leak into the structure of the game. A perfect poker player's utility function would be equal to their EV, but most players' decisions get affected by different factors such as the fear of losing money, looking stupid, or the embarrassment of being bluffed, and those psychological traits will slightly tilt decisions in one way or another, decreasing a player's

EV.

P1 EV:

$$QQ\ Ev\ [Bet] = [(100) * (1 - C\ )] + [(-100) * (C)]$$

$$QQ\ Ev\ [Check] = 0$$

Where: C = probability of P2 calling

P2 EV:

$$P2\ Ev\ [Call] = [QQ\% * 200] - [AA\% * 100]$$

Where:

AA% = probability of P1 having AA

QQ% = probability of P1 having QQ

$$P2Ev[Fold] = 0$$

At equilibrium P1 must be indifferent to betting or checking with QQ:

$$[(100) * (1 - C\ )] + [(-100) * C] = 0$$

$$[(100 - 100\ C\ )] + [-100\ C] = 0$$

$$100 - 200\ C = 0$$

$$C = \frac{1}{2}$$

P2 should also be indifferent to calling or folding with KK and, as we proved before, P1 will always bet his AA, so:

AA% = 1

Then:

$$[QQ\ \% * 200] - [AA\% * 100] = 0$$

$$QQ\ \% = \frac{1}{2}$$

To build Villain's leak into the game, we must see it from Villain's perspective. In Villain's mind, folding KK when Hero is bluffing is a -EV play by a margin of X and Hero gains that extra X when his bluff succeeds:

P1 EV:

$$QQ\ Ev\ [Bet] = [(100 + X) * (1 - C)] + [(-100) * (C)]$$

$$QQ\ Ev\ [Check] = 0$$

P2 EV:

$$P2\ Ev\ [Call] = [QQ\% * 200] - [AA\% * 100]$$

$$P2\ Ev\ [Fold] = -X * QQ\%$$

If we apply the indifference principle one more time we get:

$$[(100 + X) * (1 - C)] + [(-100) * C] = 0$$

$$[(100 - 100C + X - XC)] + [-100C] = 0$$

$$(-200C - XC) = -X - 100$$

$$C * (200 + X) = X + 100$$

$$C = \frac{X + 100}{X + 200}$$

And also:

$$[QQ\,\% * 200] - [AA\% * 100] = -X * QQ\%$$

$$[QQ\,\% * 200] - [1 * 100] = -X * QQ\%$$

$$200\ QQ\,\% - 100 = -XQQ\%$$

$$200\ QQ\,\% + X\ QQ\% = +100$$

$$QQ\,\% * [200 + X] = 100$$

$$QQ\,\% = \frac{100}{200 + X}$$

We know that Villain's calling frequency is 55%, so:

$$C = \frac{X + 100}{X + 200}$$

Then:

$$0.55 = \frac{X + 100}{X + 200}$$

$$0.55\,X + 110 = X + 100$$

$$110 - 100 = X - 0.55\,X$$

$$10 = 0.45\,X$$

$$\frac{10}{0.45} = X$$

$$X = \$22.22$$

Now that we know X, we can use it to find Hero's betting frequency with QQ:

$$QQ\% = \frac{100}{200 + X}$$

$$QQ\% = \frac{100}{200 + 22.22}$$

$$QQ\% = \frac{100}{222.22}$$

$$QQ\% = 0.45\%$$

What is Hero's EV using the new QQ betting frequency of 45% in the real game where x=0? The AA EV is still $155, so all we need to do is recalculate QQ [EV]:

$$QQ\ Ev\ [Check] = 0$$

$$QQE\ v\ [Bet] = -10$$

$$QQ\ [Ev] = [QQ\ Ev\ [Bet] * QQ\ Bet\ \%] + QQ\ Ev\ [Check] * QQC\ heck\ \%]$$

$$QQ\ [Ev] = [-10 * 45\%] + [0 * 0.55\%]$$

$$QQ\ [Ev] = -4.5$$

Then:

$$P1\ Ev = [AA\ [Ev] * AA\%] + [QQ\ [Ev] * QQ\%]$$

$$P1\ Ev = [155 * 0.5] + [-4.5 * 0.5]$$

$$P1\ Ev = 77.5 - 2.25$$

$$P1\ Ev = 75.25$$

EV Summary		
GTO EV	MinES EV	MES EV
$75	$75.25	$77.50

Table 12: Comparing MinES EV and MES EV

Of course, the MinES EV gain is not nearly as good as the MES EV gain *(Table 12)* but the extra $0.25 per hand, or $25/100 that MinES yields, is unexploitable and there is nothing Villain can do to prevent you from getting that edge unless he fixes his leak by internally reducing his value of X.

MinES can be calculated using modern GTO solvers, and unlike MES you don't need to know Villain's entire strategy. All you need is to assume a specific leak, lock that leak in Villain's strategy in the solver (allow Villain to play optimally everywhere else) and try to compensate for the observed leak later on. This way, the solver will produce an exploitative solution accounting for the leak but also for the best possible counter-adjustments that Villain can make. By doing so, you will yield a lower EV than MES while protecting yourself from counter-exploitation. Also, MinES adjustments are small and more difficult to spot by the Villain, so you can keep exploiting them far longer before they realize what you are doing if they are even capable of doing so. Finally, in the event Villain reverts to the real equilibrium, you must do so as well, otherwise you would start losing EV.

The Two sub-types of MinES

♦ **Reactive MinES:** This type of exploitation adjusts your strategy only after you have observed the leak happen in the actual hand. For example, if you knew Villain overfolds to c-bets, you would c-bet with an equilibrium strategy and then adjust the turn and river

play to account for a stronger Villain range on the later streets.

- **Proactive MinES:** This type of exploitation adjusts your strategy even before your opponent makes the mistake because you assume beforehand that they will commit the mistake. For example, if you knew Villain overfolds to flop c-bets, you can increase your c-bet frequency to exploit the leak.

I recommend using both reactive and proactive MinES. For example, vs a player who overfolds the flop vs c-bets, you should increase your c-bet frequency and then, if called, adjust your turn and river play to account for your own range being wider than normal and Villain's range being tighter than normal.

We will see more practical examples when studying post-flop play.

GTO in Multi-way Situations

The definition of Nash Equilibrium states that:

"No player can unilaterally change his strategy to improve his own expectation."

In any heads-up situation, Nash Equilibrium is very powerful because it means that a player playing GTO cannot be beaten. It is mathematically impossible even if your opponent knew your exact strategy. You are guaranteed a certain EV no matter what your opponent does. If you are playing GTO and your opponent deviates to a weaker strategy, their EV can only go down and, since poker is a zero sum game, that EV will be gained by you.

Fortunately, Nash Equilibrium principles are not limited to heads-up poker. They can also be applied to any poker situation once there are only two players remaining in the pot.

Let's look at some examples of common poker situations that can be considered heads-up subgames:

- 6-max cash game: CO raises, the BN 3-bets, the blinds fold and the action gets back to the CO. The only players remaining are BN and CO.
- MTT 9-max: UTG raises and the action folds to the BB. The only players remaining are UTG and BB.
- MTT 6-max: HJ raises, BN calls, SB 3-bets, HJ Folds and the action gets back to the BN.

The only players remaining are SB and BN.

That's great! GTO play guarantees unbeatability in any poker hand from the point where there are only two players left, but what about situations where there are three or more active players?

In multi-way situations, the EV loss by one player's mistakes are not spread equally among the other players in the hand. In most situations, some players will be able to capitalize more on the mistakes than others, depending on many factors such as stack depth and position. Furthermore, some players might end up losing EV even if they play their equilibrium strategies. Consider the following:

Example
Game: $100 3-max online Jackpot Sit & Go
Stacks: BN 12bb, SB 12bb, BB 12bb
Players: 3 (no ante)
Pre-flop: (1.5bb) BN push 12 BB, Hero is in the SB.

The Nash Equilibrium strategy for the BN is to push 32.1% hands. If we introduce a fishy player to the game who only pushes 16%, we can use a push-fold calculator to get the players' change in EV if the blinds continue playing Nash Equilibrium and if they adjust to the MES *(Table 13)*.

Big Blinds/100	BN EV	SB EV	BB EV
All Nash	22	-16.7	-5.4
BN Fish	19.8	-21.2	1.5
MES vs Fish	16.6	-19.9	3.3

Table 13: MES Adjustments

The fish is deviating to a weaker strategy and, of course, that makes them lose EV, but their mistake also makes Hero lose EV (-4.5bb/100) if Hero keeps playing GTO. Even if Hero adjusts to MES, Hero will still lose 3.2bb/100 more compared to when all players are playing Nash Equilibrium.

The BB is the biggest winner in this situation as they are capturing all the extra EV. However, if we consider future games then, on average, Hero will be in the BB as often as in the SB. Therefore, Hero will also be able to profit from this fishy player's leak.

Conclusion

Having a sound GTO core strategy and developing a deep understanding of GTO principles is the key to beating modern poker and absolutely vital in tough games.

> *However, GTO isn't meant to replace critical thinking. Regardless of how good any GTO strategy might be, players should always be aware of the opposition and be actively thinking about every action throughout the hand.*

Even in heads-up pots where playing GTO guarantees unbeatability, players can still make exploitative adjustments to further capitalize on their opponent's mistakes. For multi-way situations, GTO offers near-unexploitable strategies that can be used as a starting point but are by no means the final answer and should not be followed blindly. Understanding and incorporating GTO concepts will improve your strategy and make you a lot tougher to play against, as well as help you better exploit your opponents' weaknesses. GTO is a powerful tool in a poker player's arsenal but should not be the only one.

Poker Math Everyone Should Know

Normalizing the size of the pot to 1 and all bets as a fraction of the pot makes calculations easier. For example, if the pot is $60 and a player bets $20, his bet-size as a fraction of the pot is 1/3-pot or 0.33 pot (*Table 14*).

Bet Size	Pot Odds b/(2b+1)	Odds: X-to-1	Alpha b/(b+1)	1-A 1/(b+1)
0.10	8%	11.0	9%	91%
0.25	17%	5.0	20%	80%
0.33	20%	4.0	25%	75%
0.40	22%	3.5	29%	71%
0.50	25%	3.0	33%	67%
0.60	27%	2.7	38%	63%
0.67	29%	2.5	40%	60%
0.75	30%	2.3	43%	57%
1.00	33%	2.0	50%	50%
1.25	36%	1.8	56%	44%
1.50	38%	1.7	60%	40%
2.00	40%	1.5	67%	33%
3.00	43%	1.3	75%	25%
4.00	44%	1.3	80%	20%
5.00	45%	1.2	83%	17%
10.00	48%	1.1	91%	9%
100.00	50%	1.0	99%	1%

Table 14: Bet-sizing and Alpha

Example

If you bet half-pot with a polarized range on the river, you are giving your opponent 25% odds to call (3-to-1). Your range should have 75% value-bets and 25% bluffs (3-to-1). Your bet needs to work 33% (Alpha) of the time to instantly profit. Your opponent must defend 67% (1-Alpha) of his range to make your zero equity bluffs indifferent.

MODERN POKER SOFTWARE

Computer programs and apps have taken over modern society. Now you can find apps that do pretty much anything, including gaming, social media, communication, fitness, health, yoga, meditation, cooking, learning new languages, playing music and videos and even dating! No matter your need, there is a good chance that you can find an app that can fulfill it and if you can't, you can be sure that there is someone somewhere in the world developing it right now.

The world we live in has changed, and with it so has poker as we knew it. As technology progresses, the tools used by poker players to analyze and study the game have become more and more sophisticated. In this chapter we will analyze some of the most important programs and applications used by poker players to improve their strategies, keep up with modern developments, and crush their opponents.

Equity Calculators

Poker equity calculators have been around forever, and they are undoubtedly the most essential tool in any serious player's arsenal. Understanding how equities interact for hand vs hand, hand vs range and range vs range is the first step towards a successful poker career.

Equity calculators have come a long way since 2008 when the now deprecated PokerStove was first released. Back then, the calculators were unpolished and offered extremely limited functionality. Now, equity calculators such as *Power Equilab* (power-equilab.com) offer a wide variety of features that go beyond simple equity calculations, including equity graphs, heatmaps, range analysis and more.

Pros

- ♦ The process of entering ranges and calculating equities is intuitive and simple to use
- ♦ Multiway equity calculations
- ♦ Ability to create custom playability profiles
- ♦ Fast equity calculations

Cons

- ♦ Calculations are limited to equity and simple math
- ♦ Does not report EV or any kind of strategic advice
- ♦ Limited post-flop range analysis

Range Analysis Tools

With a range analysis tool such as *Flopzilla* (flopzilla.com) players can input hand ranges and figure out how the range interacts with any possible flop, breaking it down into hand categories such as top pair, sets, straights, flush draws, backdoor straight draws, and many more.

Pros

- ♦ Reports equity by hand combos
- ♦ Can be used to analyze card removal effects
- ♦ Post-flop filtering of hands by category across turns and rivers
- ♦ Fast calculations
- ♦ Simple to use

Cons

- ♦ Does not report EV or any sort of strategic advice
- ♦ Cannot be used to create complex decision trees
- ♦ Mostly useful for heads-up analysis
- ♦ Limited pre-flop usefulness

EV Decision Trees

With an EV decision tree tool such as *Card Runners EV* (cardrunnersev.com) you can build decision trees that represent player actions and calculate the EV of every decision point.

Pros

- ♦ Reports EQ and EV for different actions
- ♦ ICM calculations that are useful for SNG and MTT final tables
- ♦ Ability to create complex trees and scripting functionality (use of a programming language to automate tasks)
- ♦ Multiway calculations
- ♦ Useful for pre-flop and post-flop range analysis
- ♦ Comprehensive range filtering tool
- ♦ MES calculations
- ♦ Can incorporate bounties and rake into the calculations
- ♦ Accounts for card removal and bunching effects

Cons

- ♦ Requires a significant degree of user input, including player ranges at every decision point, pot size, bet-sizes, raise sizes, and stack depths
- ♦ Tree creation and strategy analysis can be very time consuming
- ♦ Requires knowledge of Villain's full strategy or the use of several assumptions to compute EV
- ♦ Steep learning curve

Pre-flop Nash Calculators

Before modern GTO solvers, Nash calculators such as *Holdem Resources Calculator*

(holdemresources.net) were the tool of choice for MTT and SNG players. They are great at approximating pre-flop push/fold strategies, particularly for shallow stacks in situations where players don't have calling ranges.

However, they do not support post-flop play, so if you try to calculate ranges for stacks that are deep enough to have non-all-in bet-sizes, you would be forced to apply action abstractions. You can either completely remove players' options to call non-all-in raises, or allow for calls, but assume no more betting will happen after the flop is dealt, having both players check their hands down. Both abstractions produce incorrect pre-flop strategies. Removing the calling option hurts the defending players by forcing them to play tighter ranges, so the calculator suggests wider opening ranges than optimal and is more biased towards having good blockers, while ignoring post-flop playability. Checking down post-flop benefits the calling player because all of their marginal hands will realize 100% of their equity, which leads to wider calling ranges than optimal. Both options limit Nash calculators' applications for deep stack poker and make them suitable for only push/fold situations.

Pros

- ♦ Great for calculating unexploitable shoves
- ♦ Fast calculations
- ♦ Pre-flop MES calculations
- ♦ Reports pre-flop strategies and EV
- ♦ Supports tournaments bounty calculations
- ♦ Independent Chip Model (ICM) and Future Game Simulations (FGS) for SNGs and MTTs
- ♦ Final table calculations

Cons

- ♦ Does not support post-flop play
- ♦ Does not account for card removal or bunching effects

GTO Solvers and Artificial Intelligence (AI)

Back in 1997, the at-the-time best chessplayer in the world, Garry Kasparov, lost to IBM super computer, Deep Blue. His defeat was taken as a sign that someday artificial intelligence would catch up with human intelligence.

Ever since Deep Blue's victory, AI has taken big steps towards humanity's final defeat. In 2015, AlphaGo, an AI developed by Deep Mind, a world leader in artificial intelligence research, became the first computer Go program to beat a human professional Go player in a full-sized 19X19 board. In May 2017, AlphaGo beat Ke Jie, the #1 world ranked player at the time. The game of Go has an order of magnitude of 10^{170}. Later the same year, Deep Mind released AlphaZero, a chess and shogi AI that took the world by storm, achieving superhuman level of play within 24 hours of release and defeating the world champion programs Stockfish and Elmo. The game of chess has a magnitude order of 10^{47} and shogi has a magnitude order of 10^{71}. However, defeating the best human players is not the same as solving the game. An AI can be good enough to beat the best humans, but then another AI could develop an even better strategy and beat the previous AI. This cycle could continue forever. Solving a game involves computing a game theory optimal solution (GTO) that is incapable of losing against any opponent in a fair game.

To date, every nontrivial game played competitively by humans that has been solved is a game of perfect information. In perfect information games such as chess or checkers, each player can see all the pieces of the board at all times. In imperfect information games such as poker, players' cards are hidden from other players. Solving these games presents an extra level of difficulty.

The game of checkers has 5×10^{20} possible moves and was completely solved in 2007 by Professor Jonathan Schaeffer. Heads-Up Limit Hold'em (HULHE) is the smallest variant of poker played competitively by humans. HULHE has 3.19×10^{14} decision points. Although it is smaller than checkers, the imperfect information nature of HULHE makes it a far more challenging game for computers to play and solve.

The first full-scale poker game solved was HULHE, solved by University of Alberta Cepheus Poker Project (2015). Their implementation of the CFR+ algorithm (counterfactual regret minimization) was executed on a cluster of 200 computation nodes each with 24 2.1-GHz AMD cores, 32 GB of RAM (6400GB of RAM), and a 1-TB local disk (200 TB Disk Storage).

More Information about Cepheus can be found at poker.srv.ualberta.ca.

On January 30th, 2017, the AI Libratus developed by Carnegie Mellon defeated top human Heads-Up No-Limit Hold'em (HUNLHE) specialists in a 120,000 hand challenge.

The size of HUNLHE is 10^{160} situations, which is more than the number of atoms in the universe (10^{82}). The AI required a cluster of super computers consisting of 600 nodes, each with 28 cores of processing power and a total of 2.7 petabytes of data, to complete the task and beat the human players.

More information about Libratus can be found here:

cmu.edu/news/stories/archives/2017/january/AI-beats-poker-pros.html

Poker bots are getting smarter every day, but with current computing power there are still some limitations to what they can do, particularly in multi-way situations with infinite bet-sizes and multiple stack depths in big bet games such as NLH and PLO. While HULHE has been fully solved and Libratus is already good enough to beat top human players in HUNLHE, other poker variations including tournaments, 6-max and full ring cash games are nowhere near to being completely solved.

Even though the full solution for hold'em games with more than two players has not been found yet, complex games can be broken down into smaller, easier to solve pieces. With the use of modern solvers, super-computers, limited bet-sizings and the correct application of strategy abstractions, good approximations to No-Limit hold'em GTO play can be calculated.

Commercial Artificial Intelligence Software

Artificial intelligence-based software for NLH, such as *Poker Snowie* (pokersnowie.com), are tools that have learned the game by playing trillions of hands against themselves. They begin with completely random strategies and, after each hand is played, successful lines get reinforced and unsuccessful lines get reduced, which results in their strategies being improved over time.

Pros

- ♦ Fast and easy to use
- ♦ Requires very little user input
- ♦ Does not have large hardware requirements
- ♦ Offers the ability to import hand histories from online games and evaluate them against the AI strategies
- ♦ Offers pre-flop and hand range advice

♦ User can play challenges, getting statistics and error evaluations

Cons

♦ Doesn't actually solve for GTO strategies; the AI tool output is instead the result of the strategies the software believes are good when playing against itself

♦ Limited or fixed bet-sizes

♦ The AI can't explain why it does what it does and results are not verifiable

♦ Cannot calculate exploitative strategies against weak players; the program only provides its core strategy

♦ Strategies change over time, which makes learning from it difficult

♦ Cannot guarantee unexploitability

GTO Solvers

Solvers are Nash Equilibrium calculators for pre-flop and post-flop play. There are several commercially available and they offer different sets of characteristics. At the time of writing, most commercial solvers can calculate Nash Equilibrium strategies for post-flop Limit and No-Limit Hold'em situations with arbitrary ranges and bet-sizes in any heads-up spot to a very high level of accuracy (low exploitability).

Some solvers can calculate the pre-flop and post-flop Nash Equilibrium for multi-way situations, and some can even solve for bigger games such as Pot-Limit Omaha.

Claiming that a strategy is GTO or very close to it has to be backed up somehow. As stated before, the complete solution to a game such as NLH hasn't been found, so if a person claims to have a GTO solution for a poker spot within a given abstraction, there must be a scientific and mathematical way to verify this affirmation, otherwise anyone could claim to have solved the game and play true GTO.

Nash Distance

Ɛ-Nash or Epsilon Equilibrium is a near-Nash Equilibrium Strategy Profile that approximately satisfies the conditions of Nash Equilibrium. Nash equilibrium strategies maximize the utility

against their Nemesis (worst case adversary), meaning that in zero-sum games it cannot lose. Nash equilibriums in complex games are not usually attainable. Instead, the term Ɛ-Nash equilibrium is used to denote strategies which only lose Ɛ to its worst case adversary.

Ɛ is also sometimes referred to as Nash distance, as it can be used to verify how close any strategy is compared to Nash Equilibrium even without knowing what the true equilibrium looks like.

Calculating the Nash Distance

Once you have a strategy pair that you think is GTO, the process to calculate the Nash distance is quite simple. First, you compute the EV of both players, then you calculate Player1's MES against Player2, see how much this EV goes up and call P1's EV gain $Ɛ_1$, then you do the same for Player2. Calculate their MES against Player1, see how much this EV goes up and call it $Ɛ_2$. The biggest number between $Ɛ_1$ and $Ɛ_2$ is the Nash Distance. If this number is 0, then you are at exact Nash Equilibrium and the strategy pair is true GTO. If this number is big, then you are far away from GTO and if you are close to GTO it will be small.

Most modern GTO solvers report their solution's Nash distance. For example, PioSOLVER reports the Nash Distance as a % of the pot and it can be used to set up a desired accuracy for the solver to finish performing calculations. Typically, the more time any GTO solution is run, the lower the Ɛ gets. Unfortunately, most GTO solvers will bounce back and forth once Ɛ is very small as they are unable to reach perfect GTO play. Once Ɛ is very small, it is unrealistic to expect any Villain to be able to exploit you for that amount, as it would first require you to play each combo on each node exactly as the solver does, then allow the Villain to know your exact strategy at every single decision point and compute the MES against your Ɛ-GTO strategy. On top of that, Villain would need to execute their MES perfectly to be able to extract all the possible EV from you. So, it is pretty safe to assume that it would be impossible for anyone to ever exploit you for Ɛ, and that you should not be worried about it. In practice, when Ɛ is small, Ɛ-GTO is no different to perfect GTO for a human player.

Personally, I like running my Flop GTO solutions to an accuracy of 0.35% of the pot. As ranges get wider, SPR increases, and the game tree complexity increases, the harder it will be to achieve a low Nash distance and the longer it will take to compute. For PioSOLVER pre-flop simulations, the pre-flop ranges will converge a lot quicker than post-flop. Most of the simulation's exploitability will come from river play, so the threshold can be lowered and exploitability can be measured in bb/100. The threshold I like for PioSOLVER pre-flop simulations is 3.5bb/100.

These thresholds are completely arbitrary, but there seems to be some consensus among the

players' community about them being good enough, as the strategies don't really change too much at lower Nash distances.

In other Solvers such as MonkerSolver, most of the exploitability comes from the suboptimal post-flop play due to the post-flop abstractions. How much of this trickles down to the pre-flop ranges is unclear, so the question of how exploitable the pre-flop ranges are, given optimal post-flop play, is impossible to answer. I ran several benchmarks and compared both pre- and post-flop simulations from Monker, Pio and a private GTO solver my team is working on and found the strategies to be very close when using high abstraction settings. Before PioSOLVER was mainstream I also ran a lot of benchmarks and tested its results with other tools, such as CardRunners EV and Nash push/fold Calculators such as HRC, and found that the results matched previous knowledge and theory.

All in all, even if the game of poker hasn't been completely solved, I'm confident that the strategies derived from the work with GTO solvers are very accurate and can be used to improve our understanding of the game of poker, helping us make better decisions at the tables which ultimately translates into EV.

PioSOLVER

PioSOLVER (piosolver.com) is the most popular solver on the market. It solves for HUNLHE equilibrium strategies with arbitrary starting ranges, stack sizes and bet-sizes to a desired accuracy (exploitability).

Pros

♦ Reports Equity, EV, EQR, and full strategies

♦ Very accurate results

♦ Can calculate MES and MinES

♦ Aggregates frequency analysis and reporting features

♦ Solves for Limit and No-Limit Hold'em

♦ High compatibility with other poker tools

♦ Advanced scripting functionality

♦ ICM Calculations

♦ Pre-flop solver (heads-up only)

♦ Outstanding customer support

Cons

♦ User interface can be overwhelming at first but, once understood, the navigation becomes simple

♦ GTO calculations can take significant time to complete, depending on the size of the tree, stack depths, and ranges in play

♦ Steep learning curve. Utilizing it effectively requires some level of poker knowledge.

♦ High hardware requirements. The complexity of the solutions is limited by the computer's capabilities, so it might require a system upgrade to run deep stack simulations with multiple bet-sizes, particularly if using the pre-flop solver.

♦ Only solves for heads-up situations

♦ Saving full simulations requires a lot of data storage, so in order to save disk space, Pio files can be saved without the river strategies, which will then be recalculated while browsing the simulations

♦ Setting up the simulations correctly can be tricky, particularly for new users. However, once the simulation has started, browsing the solutions is reasonably easy and intuitive.

MonkerSolver

MonkerSolver (monkerware.com) is the most versatile Solver on the market. It can solve Hold'em and Omaha from any street, with any number of players using several abstraction techniques to reduce the game size.

Pros

♦ Solves for complex multi-way NLH and PLO situations. However, the ability to solve

larger and more complex games comes at a cost. The use of abstractions to reduce the game size produces less accurate solutions.

♦ Finalized simulations are easy to browse

♦ ICM calculations

♦ Can adjust simulations for rake effect

♦ Equity graphs

♦ Ability to manually export ranges to other tools in various formats

Cons

♦ Graphic use interface appears rough and users can easily feel overwhelmed, particularly if not computer savvy

♦ Very steep learning curve

♦ Requires high capacity hardware. The more powerful the computer used to run Monker simulations, the better the abstraction settings that can be used, and therefore the more accurate solutions. This forces users to build super computers or rent massive servers to run high accuracy solutions.

♦ Tree building process can be tedious and time consuming

♦ Pre-flop trees can take weeks to complete, depending on the size of the tree

♦ Limited range analysis tools

♦ Lacks the ability to run aggregate reports (summarize data across multiple flops)

GTO Poker Training Web Apps

GTO training apps such as *GTO Poker* (gtopoker.io) offer a wide variety of precomputed GTO strategies for different poker variants including 6-max and heads-up cash games, MTTs, HUSNGs, and Jackpot 3-max SNGs with multiple stack depths, and more. They make advanced GTO strategies accessible to users who want to learn about GTO play but aren't necessarily

interested in running their own calculations.

Pros

- ♦ Does not require installation or sophisticated computer requirements
- ♦ Offers carefully crafted high accuracy GTO strategies developed by experts using the most advanced private and commercial GTO solvers
- ♦ Easy to use, with sleek and intuitive user interface
- ♦ Real time advice, so no need to wait for calculations to complete
- ♦ Large solutions library that grows over time
- ♦ Multiway pre-flop and post-flop solutions
- ♦ Requires minimal user input
- ♦ Rake adjusted cash game solutions
- ♦ Advanced post-flop analytics

Cons

- ♦ Fixed bet-sizes
- ♦ Can't calculate exploitative strategies against weak players (the program only provides a GTO core strategy)
- ♦ Limited to precomputed GTO solutions, so users cannot make custom calculations

Modern Poker Theory and GTO Poker teamed up to offer you a special gift. Please visit (gtopoker.io) and scan the QR code included in this book to get access to a full free month of GTO Poker.

I discuss all these tools and teach you how to use them in my training video series available on D&B Poker at dandbpoker.com/book/modern-poker-theory

THE THEORY OF PRE-FLOP PLAY

Pre-flop ranges are the backbone of fundamentally sound poker. Any time you make a mistake in a hand, you are introducing systematic error, meaning the error will be carried through and will affect future decision points. A pre-flop mistake can translate into a flop mistake, a turn mistake and finally a river mistake. Even if you realize you made a mistake on an earlier street, it can be difficult to compensate for it later.

Blinds and Antes

Without the blinds and antes, players would just happily wait to be dealt AA, or if deep enough, hands that have the correct pot odds/implied odds to beat AA, and nothing more. The blinds encourage players to fight for the money in the pot, and as a result, play more hands. The reason players play hands other than AA is because there is money in the pot to be won.

Win Rate

A player's skill edge or skill deficit over the player pool can be measured in the number of big blinds won or lost per 100 hands. The bigger the edge a player has over their opponents, the higher their win rate. If all players at the table are equally skilled, their win rates will be zero and, in raked games, they will all lose however much money the house rakes.

A player's win rate depends on the opponents' skill levels. This is why game selection is key to the success or failure of all poker players' careers. Suppose you are a skilled player and there are two different games that run at your local casino: a tough $10/$20 game where your win rate is a moderate 2bb/100, and a lower stake $2/$5 game where your win rate is 10bb/100. In the tough game, you make on average $40 every 100 hands you play but, in the smaller game, you make on average $50 every 100 hands you play. Over the long run, you will make more money playing the smaller game while experiencing a lot less variance because swings are typically higher in the bigger games where you have a lower edge.

At a 6-max cash table (with no antes), there are 1.5 big blinds in the pot every hand, or 150 big blinds every 100 hands (150bb/100). Imagine a situation where everyone was afraid to play you and, any time you raise, your opponents would fold their hands every single time, including AA. In that case, there would be no reason for you not to raise every hand with any two cards, attaining a win rate of the full pot for 150bb/100. We know that such a situation is impossible and, no matter who you are, there are some hands no player will ever fold. More importantly, there are hands they will likely re-raise (which will force you to fold some hands and forfeit their equity in the pot) and so we can conclude that no player can achieve a win rate of the full pot (150bb/100).

If no player can achieve a win rate of the full pot, how can you figure out what fraction of the pot you are entitled to capture? Or in other words, how do you determine your win rate?

Online players' win rates are quite easy to calculate by using tracking software. After playing 100,000 hands, players start to get an idea of what their actual win rate looks like, but a sample of at least 1,000,000 hands is required to be statistically significant. Live cash players can get an estimate of their overall win rate over a period of time using this formula:

$$Win\ Rate = \frac{Total\ Money\ Won}{(Big\ Blind\ Size) * (Total\ Hands\ Dealt)} * 100$$

For example, if a live player gets dealt about 300 hands over a 10-hour poker session and plays five days per week, four weeks per month, they will be dealt approximately 6,000 hands per month or 72,000 per year. If that player made $100,000 after one year of playing with $5/$10 blinds, their win rate was:

$$Win\ Rate = \frac{100000}{(10) * (72000)} * 100$$

$$Win\ Rate = \frac{5}{36} * 100$$

$$Win\ Rate = 13.89bb/100$$

Win rates tend to be a lot higher in live games compared to online games because live games are almost always softer than online games. Casinos attract all kinds of recreational players looking to gamble, socialize and have a good time. These players do not play anywhere near fundamentally sound poker, resulting in strong players having higher win rates.

Live players also lack the experience of online players. If a live player plays 300 hands per day on average then, after one year, they will have played 72,000 hands. Online poker rooms offer the possibility of multi-tabling, allowing players to play two, four, six, 10, or even 20 tables at the same time. This, combined with the faster pace of the dealing software compared to the speed of a human dealer, and the limited timebanks for decision making, results in an exponential increase in the number of hands online players get dealt. A typical online player can easily play 3,000 hands in a day, or 720,000 hands in a year. In one year, an online player will play as many poker hands as a live player will in 10 years! Of course, there are other factors that come into play and not necessarily all online players are better than live players, but this difference alone is more than enough to make the average online player a lot tougher than the average live player.

Your overall win rate is the average of the win rates you have at each position of the table. At a 6-max table, if the pot was to get split equally among all six positions, the win rate in each position would be 25bb/100 but, as we will see, there are many factors that affect players' profitability according to their position at the table. In some positions, the win rate can be higher than 25bb/100, and for others, it will be lower *(Table 15)*.

Position	Large Winner	Decent Winner	Break Even	Slight Loser	Big Loser
BB	-30	-35	-44	-45	-66
SB	-12	-15	-21	-21	-32
EP	12	10	7	6	-5
MP	18	15	12	8	-4
CO	25	20	18	15	7
BTN	35	30	28	24	17
Average	8	4	0	-2	-14

Table 15: Online 6-max Win Rate Examples (bb/100)

The win rate in the blinds is always negative. The BB starts the hand posting 1bb, and the SB posts 0.5bb, so their win rates start off at -100bb/100 and -50bb/100 respectively. Starting with such a disadvantage, no matter how good a player is, their win rate in the blinds can never be as

good as the other positions. The BN has the highest win rate because that position gets to play the most hands profitably. Win rates decrease as the position moves away from the BN.

Most players lose money when playing poker. That is a fact. You must be really good just to break even because you have to recover the -150bb/100 you lose to the blinds each round, as well as the rake the house takes.

Depending on the stakes you play and the poker site, the rake will usually be between 5 and 10 big blinds per 100 hands. Poker tracking software can be used to find the exact amount paid in rake, as well as its effect on win rates. It is often the case, particularly in online micro stakes, that the rake is so high that even strong players cannot win, so my advice to all players is to look carefully at each site's rake structure (as well as rake-back deals and VIP programs) before deciding where to play. Higher rake can never be good for the players because it only means that more money is being taken away from the tables and into the house's pocket. Note that in ante games, players also need to be able to recover the antes. An ante of 12.5% the size of the BB is equivalent to -12.5bb/100.

So, what can the players do to maximize their win rates and be able to beat the blinds and rake?

Your overall win rate is the aggregate of the EVs of all hands you were dealt in all positions and the actions you took with them. So, the way to maximize your overall win rate is simply by always taking the highest EV action with each hand you are dealt at every decision point.

EV can be expressed as a win rate in bb/100, and we know that the EV of folding is 0, so players should only play hands when the actions they can take have a non-negative win rate.

Example

9-max MTT (12.5% ante), 20bb effective stack. Action folds to the SB who has four options. Go all-in for 20bb, raise to 2.5bb, limp or fold. We know that the EV of folding is always 0. Let's take a look at the win rates of the four actions for various hands in this situation *(Table 16)*.

According to the table, the best action to take with AA is to raise 2.5bb, AJo should push 20bb, Q7s should limp and given all actions for 72o have a negative win rate, it should be folded.

Your overall win rate in the SB when the action folds to you is 88bb/100 *(Table 17)*. That is simply the aggregate EV of each one of the 1,326 possible hands. The hands with negative EV will be folded and have 0EV, and all other hands will have EV equal to the highest EV action. If you choose any action other than the highest EV for each hand vs a GTO opponent, your win rate in the spot can only go down.

Hand	Action	Win Rate (bb/100)
AA	Push 20bb	583
	Raise 2.5bb	719
	Limp	676
AJo	Push 20bb	312
	Raise 2.5bb	290
	Limp	301
Q7s	Push 20bb	68
	Raise 2.5bb	72
	Limp	74
72o	Push 20bb	-63
	Raise 2.5bb	-25
	Limp	-4

Table 16: (EVs Calculated with PioSOLVER, Assuming a GTO opponent)

For example, if you choose to go all-in with 72o, you will lose -63bb/100 on average. Going all-in with AA is +EV, but not the highest EV play. In fact, going all-in with AA is -136bb/100 worse than raising to 2.5bb, so *this mistake is even worse than pushing 72o.* It is very important that you do not make the common mistake of thinking that just because a play is +EV it is the correct play.

Any action should always be compared to all other possibilities before deciding your play.

Player	EV	EV (% Pot)	Win Rate (bb/100)
SB	35.115	33%	88
BB	69.885	67%	175
Pot	105	100%	263

Table 17: Blinds Win Rate when Folded to Them (BB 40, Stacks 800, i.e.20bb)

The more hands you can profitably play, and the higher average profitability of each hand, the higher your win rate will be. Each decision you make on every single hand increases or decreases your overall win rate. In cash games, win rates are directly proportional to the player's profitability in the games (as seen in *Table 18*), but in tournaments that is not always the case

because the value of the chips is not directly proportional to their dollar value. We will discuss tournaments later in the Tournament Theory chapter. That said, win rates can still be quite useful for tournament players as they say a lot about the player's skills and can be used to find leaks when win rates are lower than expected.

Player type	Win Rates After Rake (bb/100)	NL25 (0.1/0.25)	NL50 (0.25/0.5)	NL100 (0.5/1)	NL200 (1/2)	NL500 (2/5)
Big Winner	8	$20,000	$40,000	$80,000	$160,000	$400,000
Decent Winner	4	$10,000	$20,000	$40,000	$80,000	$200,000
Break Even	0	$0	$0	$0	$0	$0
Slight Loser	-2	-$5,000	-$10,000	-$20,000	-$40,000	-$100,000
Big Loser	-14	-$35,000	-$70,000	-$140,000	-$280,000	-$700,000

Table 18: Example of Players' Profitability in Cash Games After 1,000,000 Hands Played at Different Stakes

Although the differences in win rates can seem small, they quickly add up as the stakes and sample size increase. If higher win rates translate to higher winnings, your aim, as a poker player, should be to increase your win rate as much as possible by consistently taking +EV spots and avoiding -EV spots. In the long run, the players who make the best decisions on average will end up with all of the money and the players who make the most mistakes will inevitably lose.

Complex Strategies

Why do players employ complex strategies? Why don't they just implement a simple push/fold strategy, getting it in with the good hands and folding the bad ones?

This section will compare two of the simplest pre-flop situations in order to understand the value of having different strategic options and playing complex strategies.

Situation 1: Hero is in the SB playing OOP vs the BB
Game: 3-max SNG
Stack depths: *8bb, 10bb, 12bb, 15bb, 17bb, 20bb & 25bb*
Blinds: 0.5bb/1bb
Players: 3 (no ante)

Pre-flop: (1.5bb) BN folds and the action is on Hero in the SB. He can fold, limp, raise to 2bb, to 2.5bb, to 3bb, or push all-in.

Situation 2: Hero is on the BN playing IP vs the BB
Game: Heads-up SNG
Stack depths: 8bb, 10bb, 12bb, 15bb, 17bb, 20bb & 25bb
Blinds: 0.5bb/1bb
Players: 2 (no ante)
Pre-flop: (1.5bb) Hero is first to act on the BN. He can fold, limp, raise to 2bb, to 2.5bb, to 3bb, or push.

The two situations described are very similar. Hero is in the SB in both, but Situation 1 is a 3-max game so Hero is OOP vs the BB whereas Situation 2 is heads-up vs the BB, meaning Hero has the BN and will be IP post-flop. If both players were playing a push/fold only strategy with no post-flop play, the situations would be equivalent. However, if we solve the spot using modern pre-flop solvers and give the players additional strategic options such as limping and the ability to use different raise sizings other than all-in, we can compare the different situations and try to get some insights about the value of the various strategic options and how they are affected by position.

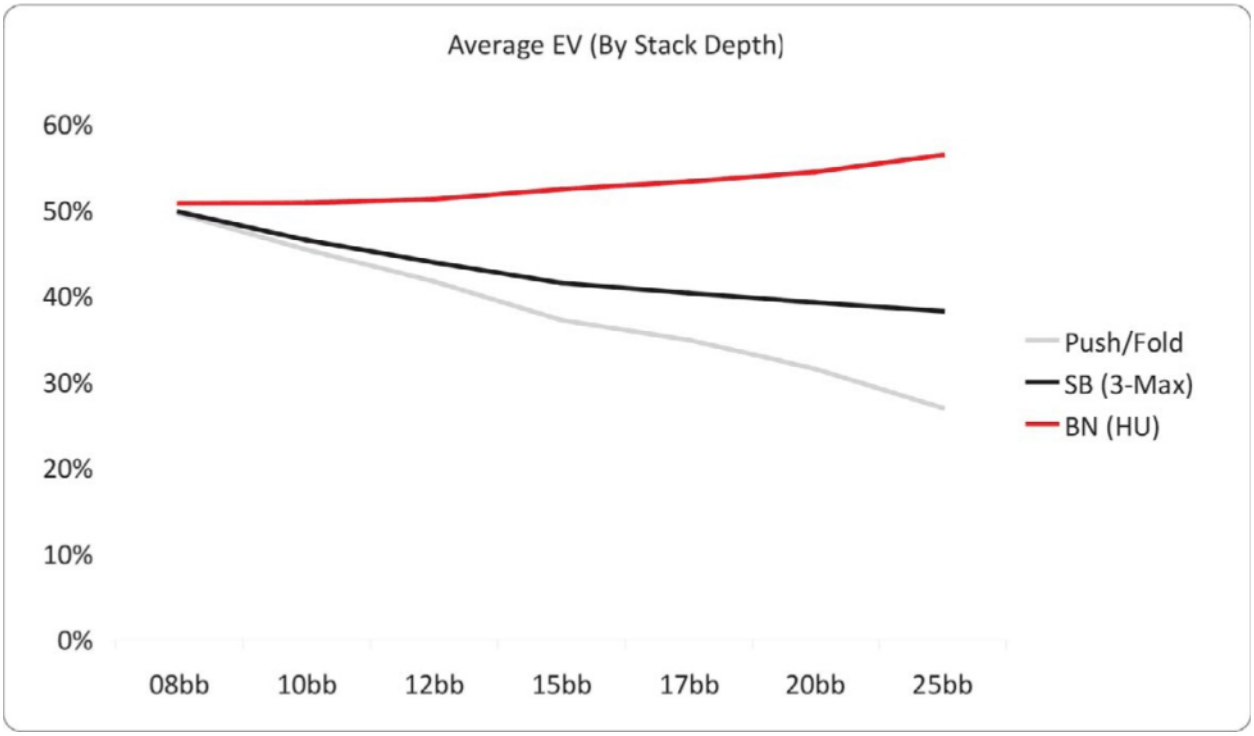


Diagram 2: Average EV by Stack Depth

Situation	EV (%Pot)	EV (bb/100)
Push/Fold	38.22%	57.32
SB (3-Max)	42.84%	64.25
BN (HU)	52.82%	79.23

Table 19: Average EV for Different Strategies

We see that by playing a more complex strategy than push/fold, Hero captures a larger portion of the pot, an extra 4.62% pot (7bb/100) when out of position and 14.6% pot (22bb/100) when in position. With very shallow stacks, the EV loss of applying a push/fold only strategy is very small, but as stacks get deeper, and particularly when having position, the value of other strategic options increases. Playing a more complex strategy than push/fold yields Hero a higher payoff.

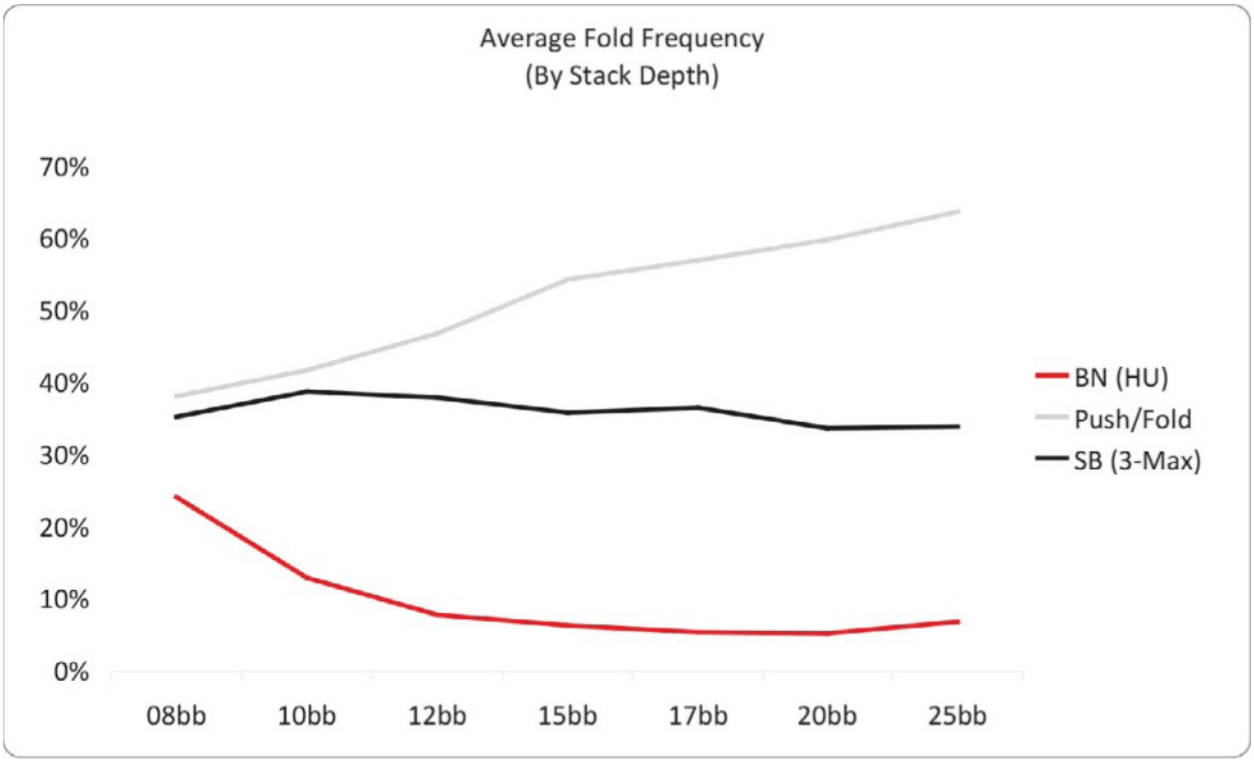


Diagram 3: Average Fold Frequency by Stack Depth

Situation	Average Fold Frequency
Push/Fold	51.63%
SB (3-Max)	35.97%
BN (HU)	9.81%

Table 20: Average Fold Frequency

Hero's folding frequency is the highest when playing push/fold *(Table 20)*, which means that this strategy limits the number of hands Hero can profitably play, particularly as stacks get deeper. Conversely, the folding frequency is lower when playing a more complex strategy, especially when having position.

With over 17bb, pushing is very rarely used by the BN, but becomes the dominant strategy with fewer than 10bb. The SB pushing frequencies are a lot higher than BN because going all-in diminishes the disadvantage of being OOP.

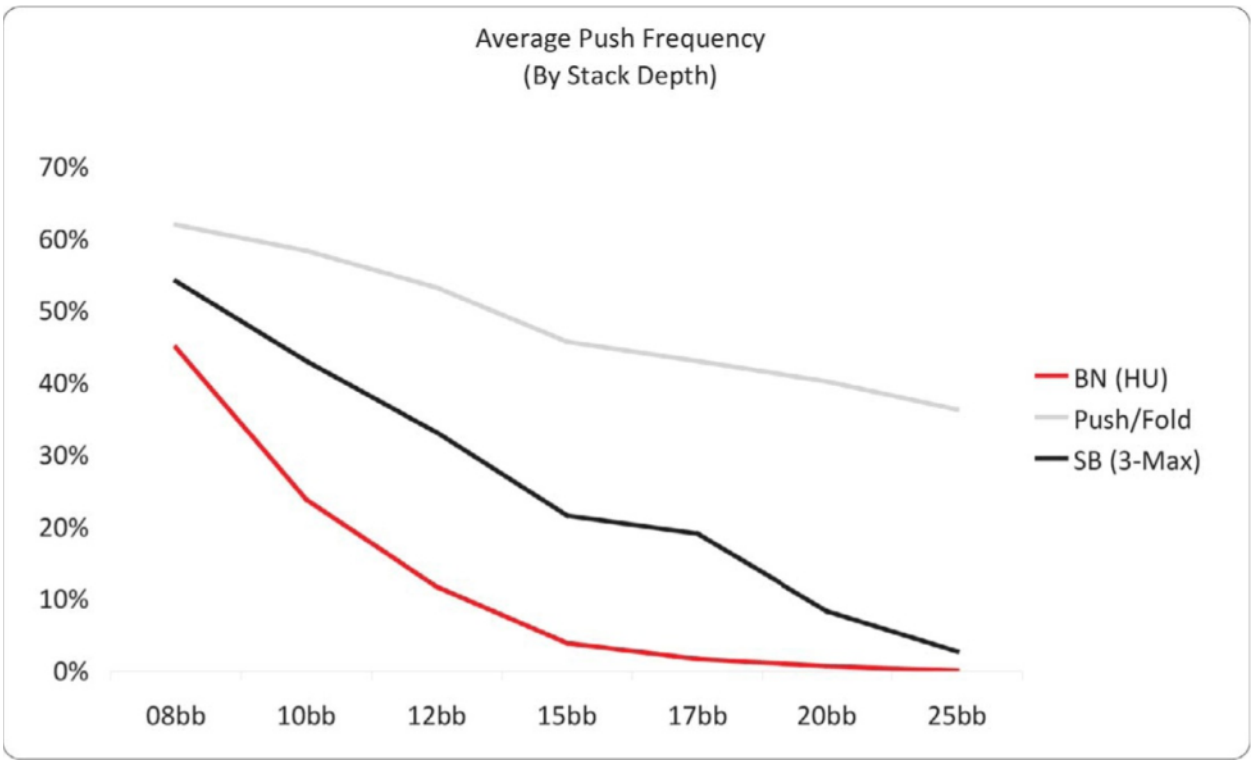


Diagram 4: Hero Push Frequency by Stack Depth

Situation	Average Push Frequency
Push/Fold	48.37%
SB (3-Max)	25.98%
BN (HU)	12.38%

Table 21

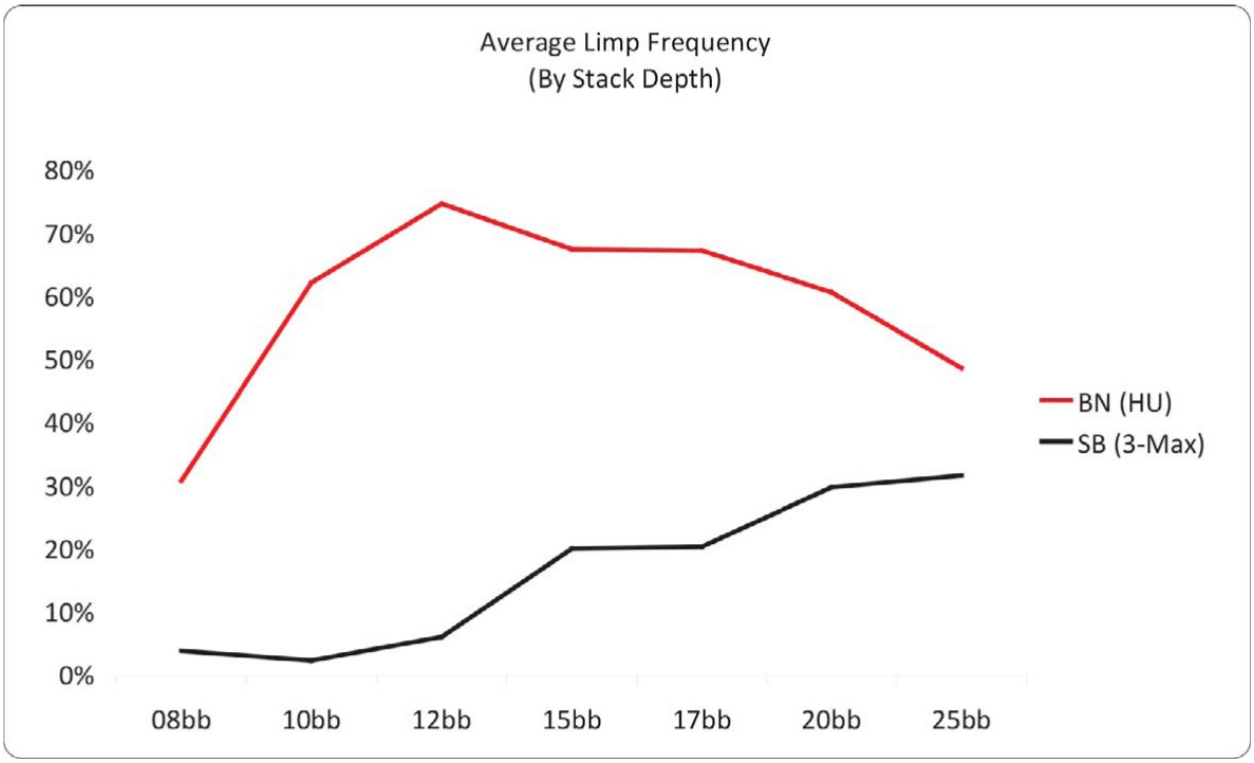


Diagram 5: Hero Limp Frequency by Stack Depth

Situation	Average Limp Frequency
SB (3-Max)	16.32%
BN (HU)	58.83%

Table 22

Limping is used 42.51% more often when Hero is IP compared to OOP, becoming the dominant strategy *(Table 23)*. Notice how limping becomes more important for the SB as stacks get deeper but remains relatively constant for the BN. This means that when Hero is IP, limping is almost as important at all stack depths, and when Hero is OOP, limping becomes more valuable as stacks get deeper when Hero loses the ability to open push very wide.

Situation	Push	Raise 3bb	Raise 2.5bb	Raise 2bb	Limp	Fold
SB (3-Max)	25.98%	5.26%	8.08%	8.39%	16.32%	35.97%
BN (HU)	12.38%	0.00%	0.00%	18.98%	58.83%	9.81%

Table 23: SB Average Frequencies (8-25bb)

The only raise size BN uses is to 2bb (min-raise). Other bet-sizes are used only when Hero is in the SB, so we can conclude the bigger sizings benefit Hero when OOP, but don't add much value when playing with position.

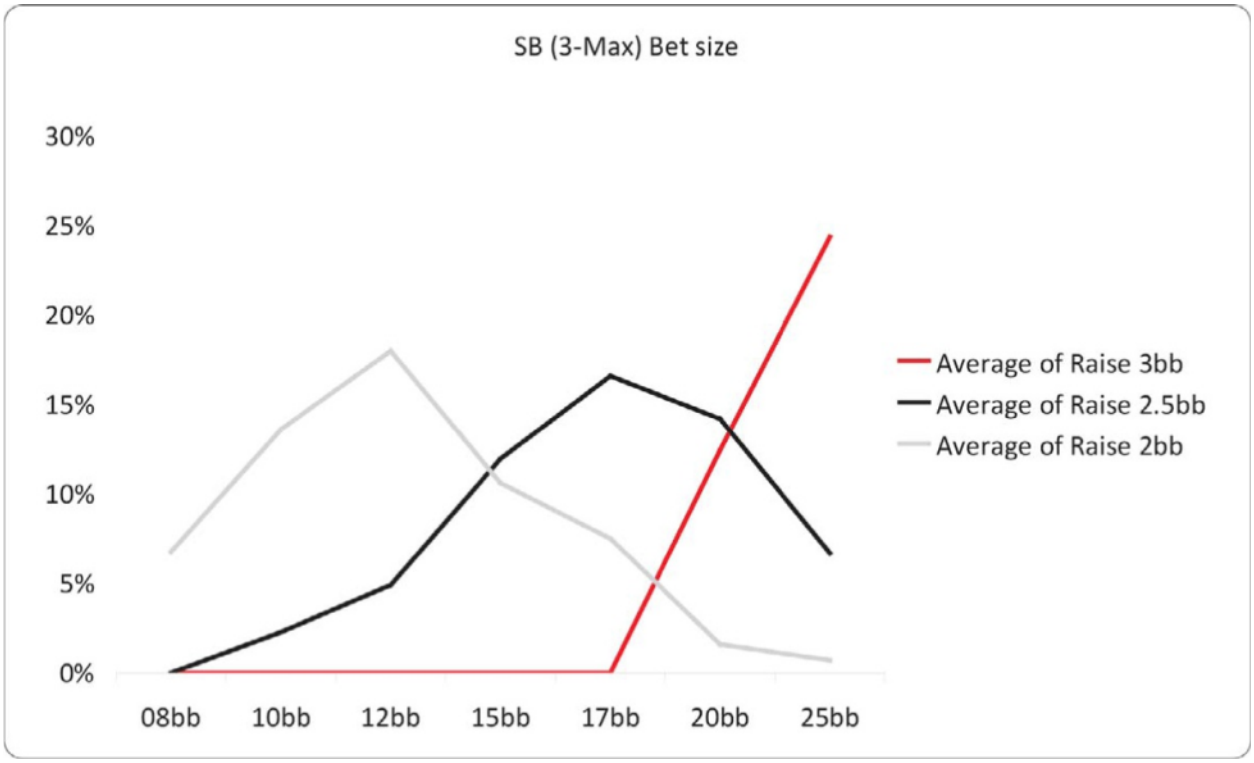


Diagram 6: Small Blind (3-Max) Bet-sizing

Minraising is the dominant strategy at the shorter stack depths (when OOP), but starting with 15bb stacks, 2.5x becomes dominant. 3x begins to be used at 20bb and becomes dominant at 25bb *(Diagram 6)*. So, we can conclude that when playing out of position, bet-size should increase as stacks get deeper.

Conclusion

Having access to more strategic options increases the player's expectation. However, some strategic options are used so rarely and their overall EV impact is so small that the cost of implementing them in your strategies may surpass the value they add. In fact, adding too many low EV/low frequency strategic options to your overall strategy can hurt your expectation. The more complex the strategy, the more difficult it is to implement so, in practice, you should strive to simplify your strategies as much as possible in order to minimize mistakes without hurting your overall expectation.

In our heads-up example, the simplest possible strategy is push/fold, and it can be applied for most spots with 10bb and shorter stacks. When out of position, pushing remains vital up to 17bb, but the BN pushes only 3.88% of hands with 15bb, 1.70% with 17bb, 0.69% with 20bb, and 0.06% with 25bb. So, the BN strategy can be simplified to never push with 15bb or more and the overall EV of the BN won't be hurt significantly. However, the limping strategy is dominant for the BN, so any strategy that removes BN limps in a heads-up game will significantly hurt its overall EV.

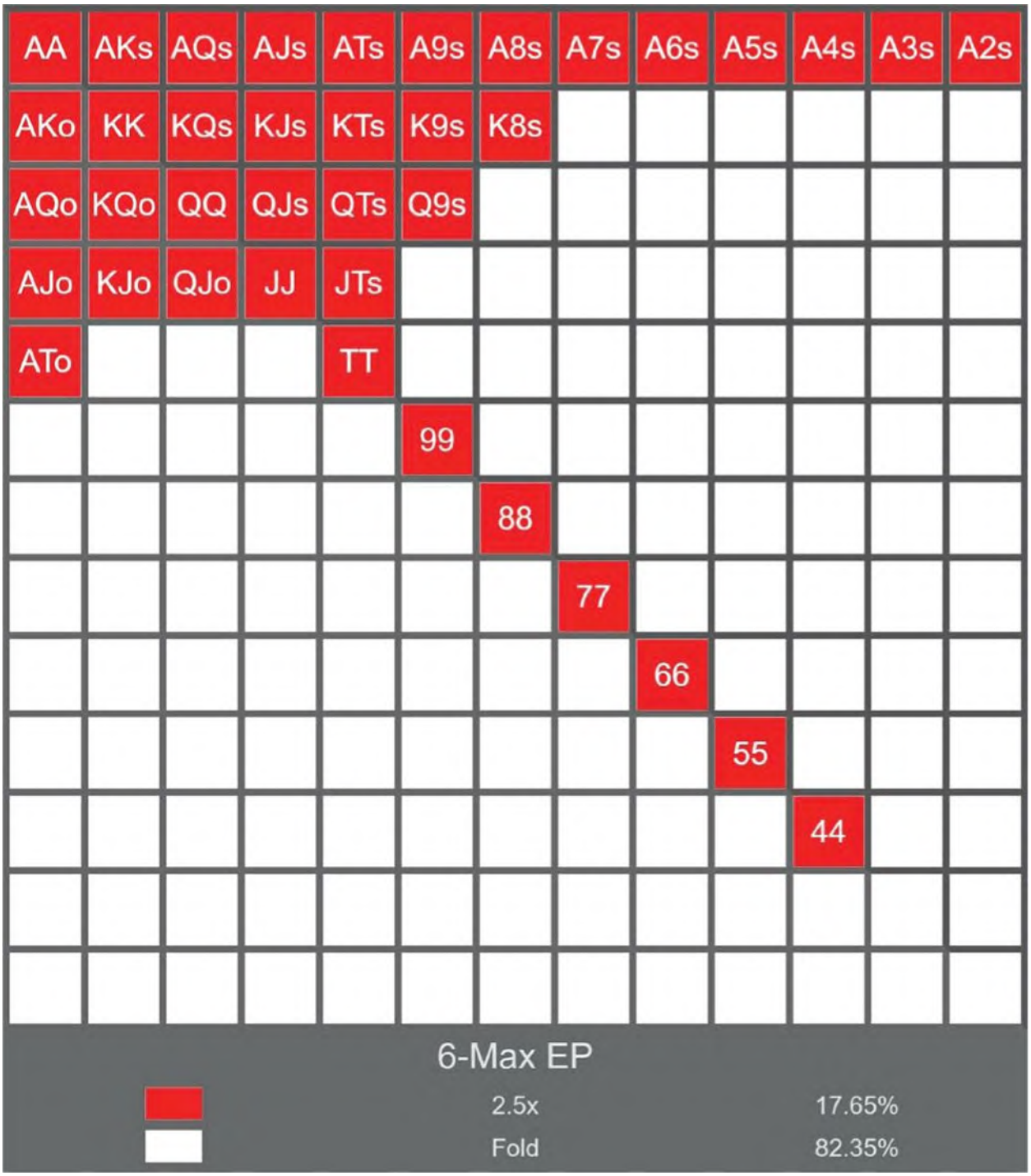
Corollary: If playing vs an opponent who we think has superior skill, then playing a complex strategy only benefits the stronger player because they will be capable of capitalizing on all the different strategic options better than you are. Thus playing a simpler game helps reduce this superior Villain's edge by minimizing your mistakes. For example, if playing heads-up in an MTT, it doesn't matter if you are against the best player in the world if you get it all-in pre-flop with a coinflip like AJs vs TT. You will win ~50% of the time, which is a great result when facing a player who has a huge edge on you.

Playing First In

Knowing what to do when the action gets folded to you is perhaps the single most important thing players must learn in their entire poker careers, yet I still see professional players simply not caring. They mistakenly think they can outplay anyone regardless of their holdings and make massive fundamental mistakes that cost them dearly in the long run.

Starting with sound pre-flop ranges improves pre-flop decision making. By systematically analyzing the game, strong players come to the tables prepared with preset strategies for the most common situations that get repeated over time. This is similar to chess grandmasters who memorize the early moves of the most important openings and pre-develop defenses rather than trying to re-invent them every game. By committing the basic moves to memory, they can focus their brain power on more complex aspects of the game in order to stay ahead of their opponents.

A typical online 6-max Cash EP-RFI range can be seen in *Hand Range 27*.



Hand Range 27: A Typical Online 6-max Cash EP RFI Range

Not everyone will play this exact RFI range, but most serious players will play some variation of it. A player who knows more or less what an EP RFI Range looks like will have a huge advantage over a player who has never studied the spot before. Instead of hesitating and wondering whether or not they are supposed to open hands such as JTo, the prepared player

knows JTo is not a standard open and will be aware of spots to expand or shrink their range if they see an opportunity to exploit a weakness in the other players. Rather than second guessing themselves all the time, a player who has done the work off the tables will consistently recognise familiar situations that they will already know how to approach, while their opponents may be clueless. When they encounter a completely new situation, a player who has studied poker theory can extrapolate results from other known situations and will make way fewer mistakes compared to a player who is oblivious to the underlying principles of the game.

Well-constructed pre-flop ranges also make post-flop play easier, because they will have the right board coverage and better playability than improvised strategies. There is a lot to be gained by developing a solid, well-balanced GTO pre-flop baseline strategy. That said, a baseline pre-flop GTO strategy should only be a starting point. The strongest players are those who can adapt as circumstances require. Once you have developed sound and balanced strategies for yourself, it becomes a lot easier to spot when your opponents have not, allowing you to easily realize when they are unbalanced and exploitable.

Just as in chess, the rules of poker are quite easy to learn, but there are many underlying principles that govern the game. Understanding those principles is the key to success. In the next section we are going to study those principles and develop the building blocks players need to understand to play solid pre-flop strategies.

Main Variables that Affect Pre-flop Hand Ranges

Absolute Hand Strength

Although hand strength is relative to the composition of the ranges in play, it can sometimes be helpful to think about hand strength in a vacuum. This is known as *absolute hand strength*. Below are the principles used to determine a poker hand's absolute hand strength.

High Card Value: The higher the cards in your hand, the stronger the hand tends to be. A hand with an ace in it will be stronger than a hand with a king in it which will be stronger than a hand with a queen in it and so on.

Pocket Pairs: Applying the high card principle to a pocket pair it follows that the higher the pocket pair rank, the stronger and more valuable it is (KK>55).

Suitedness: All things being equal, a suited hand will be stronger than an offsuit one. First of all, they have more raw equity than their offsuit counterparts and the playability of suited hands is much better. For example, A♥5♥ is preferable to A♥5♦ because A♥5♥ has the ability to flop nut flushes and the flushes it makes are more disguised than the ones made with a single ace and

four suited cards on the board, making it more likely to get paid when it hits.

Connectedness: Hands with cards closer in rank to each other are preferred to hands with gaps in between. For example, T9 is preferable to T8 and T7 because T9 has more ways to make straights than the other hands: T9 can make a straight on KQJ, QJ8, J87, and 876, and three of those are nut straights. T8 can make a straight on QJ9, J97, and 976, and only two of those are nut straights. T7 can make straights on J98 and 986 with only one straight being the nuts.

In general, the best poker hands have at least two of these components. Hands that lack high card value can compensate by having great connectedness and suitedness, such as 87s, and hands that lack suitedness can have great high card value such as AKo.

As a rule of thumb, the earlier your position at the table, the higher absolute high card strength your hand must have to be playable. As you get into later positions, weaker absolute hand strength hands can be played. For example, in a 6-max cash game with no ante, the BN can profitably play hands as weak and disconnected as Q2s, but from the LJ, the weakest Qx that can be played is Q9s.

The Size of the Pot

As the pot gets larger in terms of big blinds, more hands can be played profitably. For example, in a 9-max MTT with 12.5% antes, the size of the pot is 2.625bb. If the action gets folded to the BN, they can push 10 big blinds with 46% of hands, but without antes, the pot size is only 1.5bb, and then the BN can only push 33% of hands.

Bet-size

In general, the bottom of your range contains hands that have a low profitability (or are indifferent), so the bigger your bet-size relative to the pot, the fewer hands you can profitably play. By betting larger, you risk more, meaning you lose more on average with your weak hands when you face a re-raise and have to fold. Ideally, you want to lose as little as possible when your steals fail.

Likelihood of Being Raised/Re-raised

As seen when we studied MDF, if Villains do not defend often enough, you can exploit them by opening more hands than you would normally be able to. You may even be able to blatantly bet or raise 100% of hands in some spots. Conversely, against good/optimal opponents, there is a cap to the number of hands you can profitably play at any given time because they will play back at

you and force you to fold pre-flop, denying your equity in the pot.

Example
Game: Live Cash Game
Effective Stack: 100bb
Blinds: 0.5/1
Players: 6 (no ante)
Pre-flop: (1.5bb) Hero is in the SB with Q7s and raises to 3bb. What can the Villain in the BB do to make this raise have a negative win rate?

$$Q7s\ [Ev\ Raise] = [(Ev\ of\ Fold) * (\%\ Villain\ Folds\ )] + [(Ev\ Called) * (\%\ Villain\ Calls)] + [(Ev\ Reraised) * (\%\ Villain\ Raises)]$$

$$Q7s\ [Ev\ Raise] = [(1.5) * (\%\ Villain\ Folds\ )] + [(Ev\ called) * (\%\ Villain\ Calls)] + [(-2.5) * (\%\ Villain\ Raises)]$$

$$Q7s\ [Ev\ Raise] = [1.5 * (\%\ Villain\ Folds)] + [(Ev\ Called) * (\%\ Villain\ Calls)] - [2.5 * (\%\ Villain\ Raises)]$$

The EV of Q7s when called is always a positive number because Q7s has a certain amount of equity in the pot. Even if Villain could somehow make Q7s realize 0% of its post-flop equity, the worst that could happen is that Hero wins 0% of the pot. The only way Villain can make your raise unprofitable is to increase their 3-bet frequency, so let's figure out how often Villain needs to 3-bet to make the Q7s raise unprofitable.

For simplicity we assume Villain will only 3-bet or fold, and that Hero always folds Q7s vs a 3-bet, so:

$$Q7s\ [Ev\ Raise] = [1.5 * (1 - \%\ Villain\ Raises)] - [2.5 * (\%\ Villain\ Raises)]$$

To find the values that make the EV of raising Q7s negative we make:

$$1.5 - 1.5 * \%\, Villain\ raises - 2.5 * \%\, Villain\ raises < 0$$

$$1.5 - 4\%\, Villain\ Raises < 0$$

$$-4\%\, Villain\ Raises < -1.5$$

$$\%\, Villain\ Raises > \frac{1.5}{4}$$

$$\%\, Villain\ Raises > 0.375$$

If Hero gets 3-bet more than 37.5% of the time, opening Q7s becomes -EV. Of course, in a real poker game, the BB will never 3-bet 37.5% vs the SB, and if they did, they would be opening up to serious exploitation.

It is worth noting that the likelihood of getting 3-bet increases as there are more Villains yet to act. Imagine that instead of the SB, Hero's position is UTG. How often can Hero expect to get 3-bet at a 9-max table?

On average, we can expect Hero to be 3-bet roughly 7% of the time by each player yet to act. Ignoring blocker effects, the total frequency Hero can expect to get 3-bet is:

$$Total\ 3bet\ Freq = 1 - (1 - 3bet\%)^{Villains}$$

$$Total\ 3bet\ Freq = 1 - (1 - 0.7)^{8}$$

$$Total\ 3bet\ Freq = 1 - (0.93)^{8}$$

$$Total\ 3bet\ Freq = 1 - 0.56$$

$$Total\ 3bet\ Freq = 0.44$$

At a 9-max table with eight villains left to act, Hero can expect to be 3-bet ~44% of the time. Assuming Hero will fold to a 3-bet, raising Q7s has a negative win rate:

$$Q7s\ [Ev\ Raise] = [1.5 * (1 - \%\ Villain\ Raises)] - [2.5 * (\%\ Villain\ Raises)]$$

$$Q7s\ [Ev\ Raise] = [1.5 * (1 - 0.44)] - [2.5 * (0.44)]$$

$$Q7s\ [Ev\ Raise] = [(1.5 - 0.66)] - 1.1$$

$$Q7s\ [Ev\ Raise] = 0.84 - 1.1 = -0.26$$

Ignoring opponents' calls, the win rate of raising to 2.5x from UTG with Q7s at a 9-max table is -26bb/100.

The number of hands a player can profitably RFI depends on the likelihood of being 3-bet. Since the likelihood of being 3-bet increases as there are more players yet to act, as your positional advantage increases you can profitably raise with more hands (this is the main reason players get to play more hands from the BN than from UTG).

Rake Effect

When the rake is taken from the pot, it has an effect on players' strategies because it reduces the profitability of all hands being played. Many hands that are marginally +EV raises or calls become -EV and lose money over the long run. One of the main reasons cash games tend to have larger bet-sizings than tournaments is to discourage calls. Since the rake is paid in tournaments along with the buy-in, it has no effect on the profitability of the hands played in-game, allowing for more passive play in tournaments compared to cash games with high rake. In general, the higher the rake, the tighter the pre-flop ranges should be. Aggressive actions that can take the pot down pre-flop will take precedence over passive actions.

Example
Game: Online heads-up Cash Game
Effective Stack: $1,000
Players: 2
Blinds: $5/$10 (no ante)

Pre-flop: Hero in the BN

Let's compare Hero's BN GTO strategy without rake compared to a $5/$10 game with a 4.3% Rake, $2.20 maximum structure.

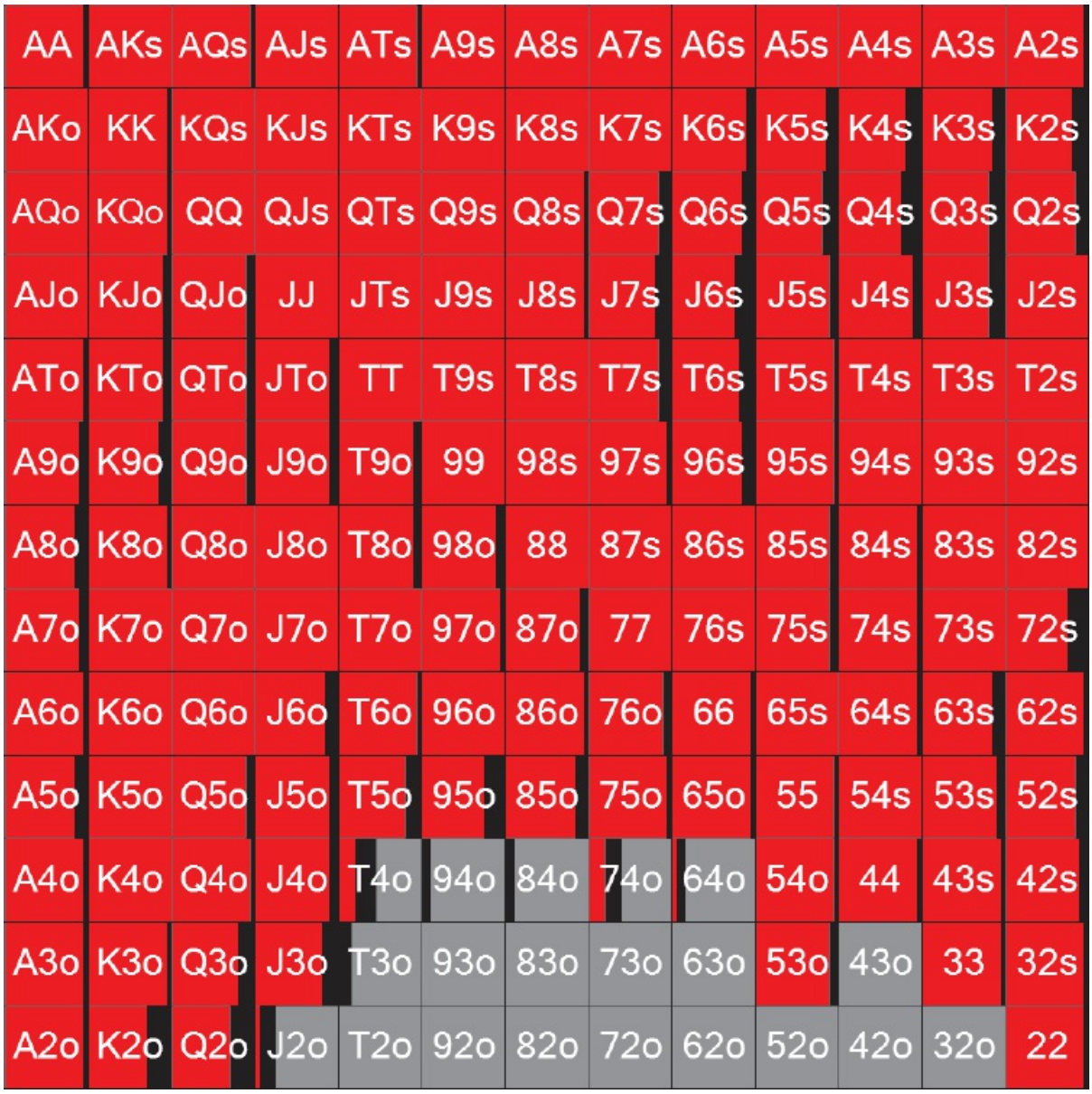
As we can see, when rake is a factor, raising frequency increases, limping frequency is reduced, and more hands get folded *(Hand Ranges 28 and 29)*.

Next, let's make the same comparison for the BB strategy facing a 2.5bb raise from the SB *(Hand Ranges 30 and 31)*.

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

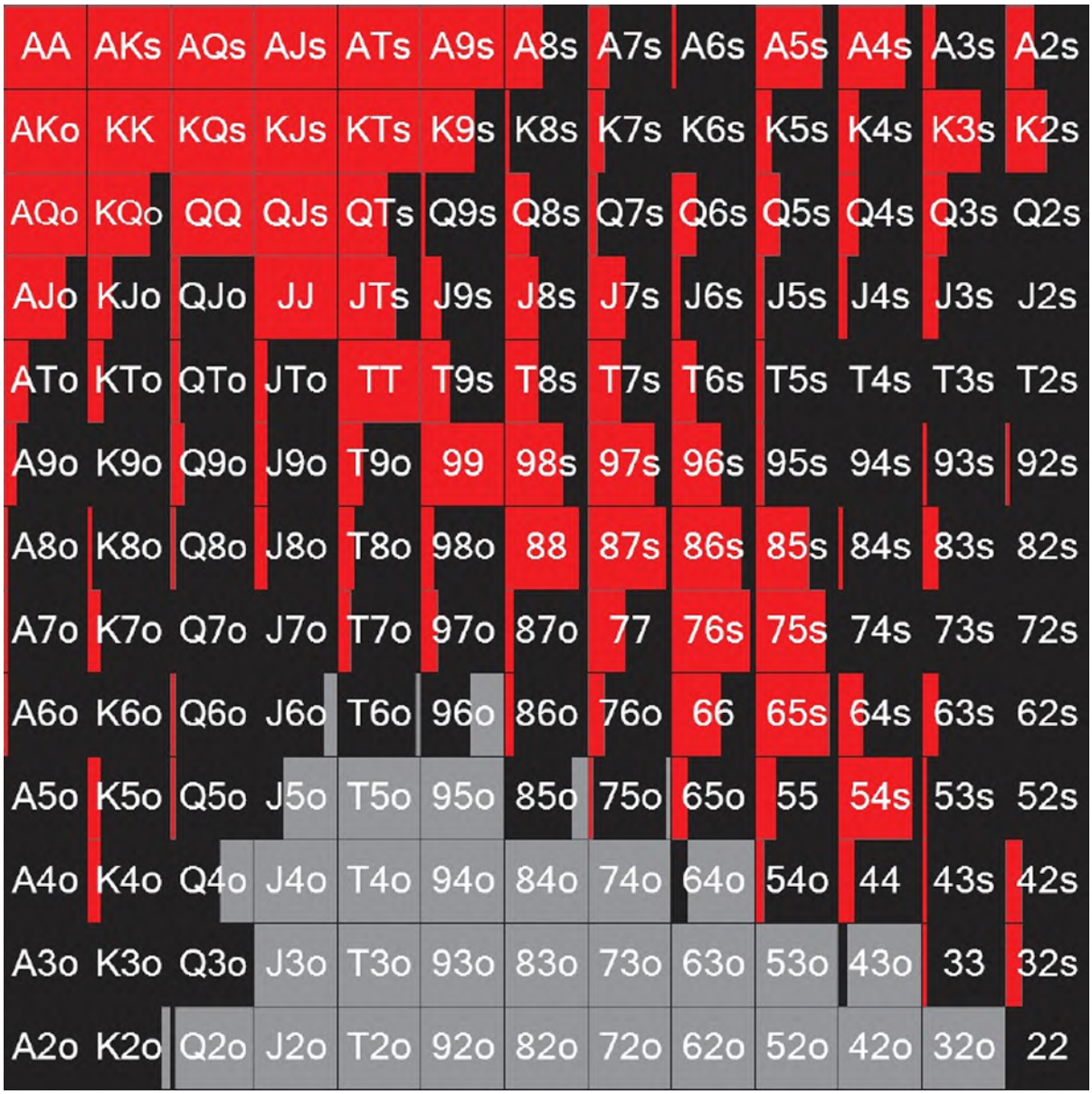
Hand Range 28: Heads-up BN GTO strategy (No Rake)

• Raise 2.5bb 70.1% / • Limp 18.3% / • Fold 11.6%



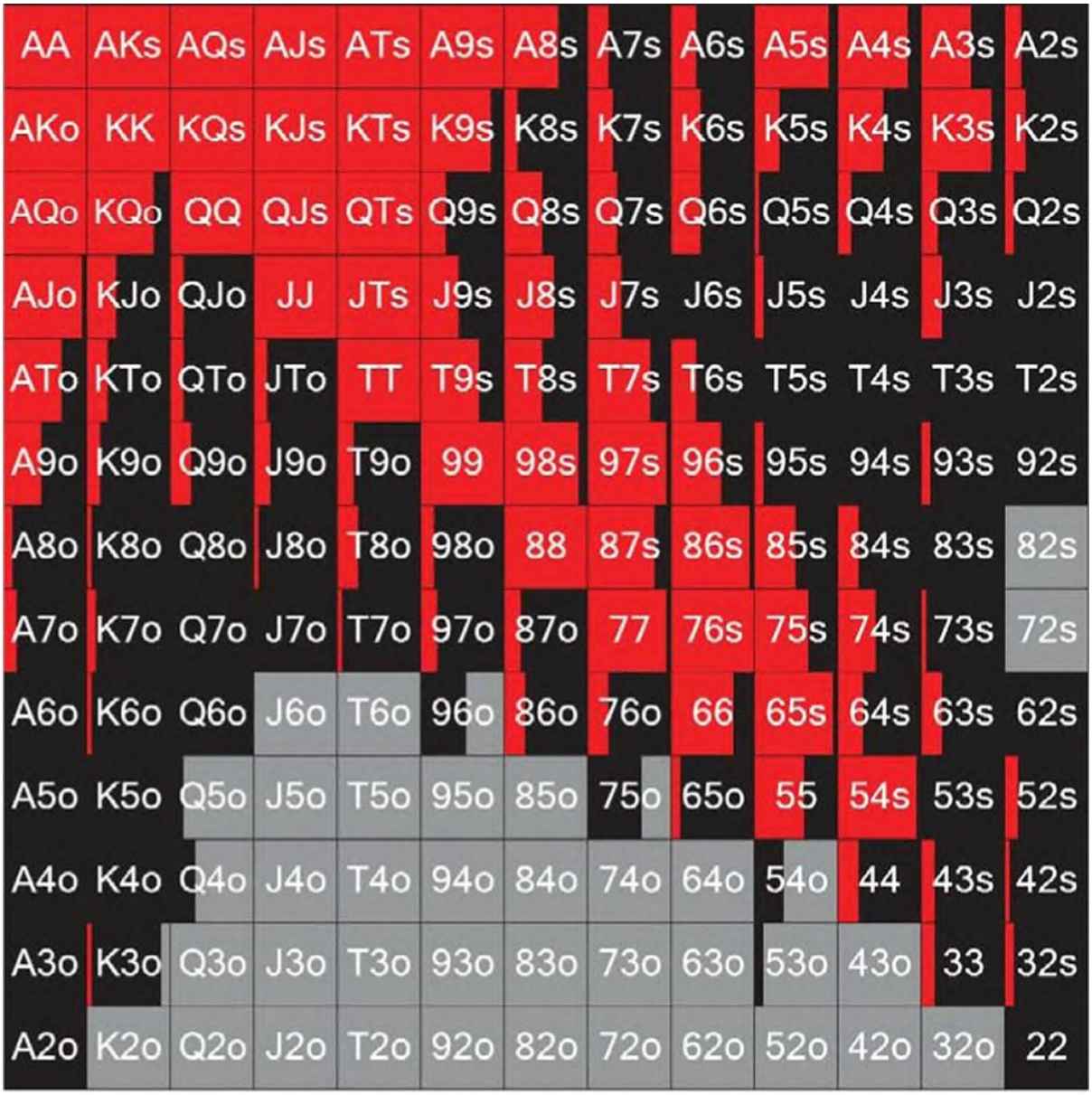
Hand Range 29: Heads-up BN GTO strategy (Rake Adjusted)

• Raise 2.5bb 76.4% / • Limp 6.9% / • Fold 16.7%



Hand Range 30: Heads-up BB vs BN 2.5x Open GTO strategy (No Rake)

• 3Bet 10bb 19.9% / • Call 55% / • Fold 25%



Hand Range 31: Heads-up BB vs BN 2.5x Open GTO strategy (Rake Adjusted)
• 3Bet 10bb 22.7% / • Call 45% / • Fold 32.3%

Again, for the BB rake-adjusted solution we see an increase in raising frequency, a decrease in calling frequency and more folding than in the solution with no rake.

Bunching Effect

Folding ranges have an impact on the hand distribution of the players left to act. For example, at a 9-max table, after six folds, the BN's raise first in range has to be tighter at a 3-max table

because other players have already folded “weak” hands, meaning the likelihood that the blinds have a strong hand increases.

In *Table 24* we can see how pushing ranges generated with MonkerSolver change due to the bunching effect for different stack depths at different table sizes (12.5% ante). These results are compared to those of the traditional push/fold calculator HRC (which ignores the bunching effect).

Stack (bb)	Monker Push %								Bunching Effect	Average Bunch-ing by Position
	HU	3-max	4-max	5-max	6-max	8-max	9-max	HRC		
10	58.4%	56.9%	54.8%	54.4%	54.1%	52.6%	52.1%	58.3%	6.3%	
12	53.2%	52.2%	51.0%	50.7%	49.1%	48.2%	48.4%	53.2%	5.0%	**4.9%**
15	45.7%	44.9%	44.0%	43.9%	42.7%	42.5%	42.2%	45.6%	3.5%	
10		32.7%	32.1%	31.5%	31.2%	31.0%	30.8%	33.0%	1.9%	
12		32.1%	31.5%	31.4%	31.1%	29.6%	29.4%	31.9%	2.7%	**2.2%**
15		27.8%	27.4%	26.9%	26.6%	26.0%	25.8%	28.1%	2.0%	
10			25.5%	25.0%	24.7%	24.0%	23.7%	25.7%	1.8%	
12			22.9%	22.2%	21.1%	21.2%	20.8%	22.9%	2.1%	**1.7%**
15			18.6%	18.4%	18.3%	18.3%	17.5%	18.7%	1.1%	
10				19.8%	19.2%	18.8%	18.6%	20.1%	1.2%	
12				16.9%	16.6%	16.6%	16.4%	17.2%	0.5%	**0.9%**
15				14.3%	13.9%	13.6%	13.3%	14.1%	1.0%	
10						15.2%	14.7%	15.9%	0.5%	
12						12.7%	12.7%	13.9%	0.0%	**0.3%**
15						10.5%	10.1%	10.9%	0.4%	

Table 24: The Bunching Effect

Accounting for the bunching effect, the SB has to push on average 4.9% tighter than traditional push/fold calculators suggest, BN has to be 2.2% tighter, CO 1.7%, HJ 0.9%, and LJ

0.3%. The earlier the position, the lower the bunching effect because fewer players have folded, hence in early position, the bunching effect can be dismissed because it approaches zero.

Limping

It is important to also discuss the possibility of limping and also what strategy to adopt when facing limpers.

Open Limp

Limping allows you to play a wider distribution of hands by investing the minimum amount possible, but the tradeoff is having to play post-flop most of the time allowing your opponents to realize equity they would have otherwise folded. Additionally, developing a limping strategy involves splitting your ranges early, which gives your opponents a lot of information about your hand strength.

For example, if you only limp hands such as small pairs, weak suited aces and suited connectors, your opponents will be able to play well against you because some flops will hit you quite hard while others will miss completely. If you limp only medium strength hands, your opponents get to raise aggressively because you never have hands strong enough to re-raise. This will force you to start limping some strong hands to balance your limping range, which will weaken your raising range. Then you will still have the problem of having a capped range on many flops after you limp/call because you no longer have the top of your range (because you will have limp/re-raised your strongest hands).

While this analysis may sound grim, limping strategies do have their place in GTO play. Solvers like applying them primarily in blind vs blind battles in rake-free environments such as tournaments. However, given the nature of modern games where most player populations under-defend their blinds, over-fold to c-bets, don’t 3-bet often enough, and don’t peel as often as they should (even in tough games), raising has a lot of added value and will remain the dominant strategy for some time to come. Despite the obvious advantages of raising in today’s games, due to the proliferation of solvers and GTO strategies, I expect to see an increase in the use of limping strategies in the future, especially in tournaments.

For the scope of this book, limping strategies will be limited to situations where the EV they add to your overall strategy is significant, particularly when playing vs tough opponents.

Facing Limpers

It is very infrequent to see open limps in modern online poker, unless you are playing microstakes. In live games, however, limping happens far more often, and the reason for this is the exact same reason it happens in online microstakes: the presence of very weak players.

For the reasons outlined earlier, most strong players won't implement limping strategies, so in general if you see a player open limp from any other position than the SB you can pretty safely assume they aren't a really strong player. If that's the case there are a few different ways you can attack them depending on the type of player they are.

Weak Passive

If the limper is the type of player who rarely raises and tends to check-fold when they miss, you can isolate them with a very wide range and expect to take down the pot post-flop with a very high frequency.

How wide you can isolate this player will depend on the other players at the table. If they are willing to attack you with 3-bets you should be careful and raise a similar range to what you would open from that position if the action was folded to you. If they will be calling a lot of raises which will lead to multi-way pots, you need to have hands that play well in multi-way pots such as suited connectors, pocket pairs and Axs. If the players behind you are not aware or aggressive, you can get away with raising almost anything that has some playability.

Sticky

If the limper is the type of player who doesn't like to fold, you should play hands that will flop good top pairs and then take them to value town. Against this type of player, any top pair and most second pairs are good enough to value-bet for three streets.

It is fine to semi-bluff against them but if your draw bricks on the river be ready to give up most of the time and never run stone cold bluffs. There is nothing they love more than calling down with bottom pair across all three streets to be shown the old airball!

Aggressive

If the limper is very aggressive and will be check-raising and leading against you, do yourself a favor and don't isolate this player too wide. Your range should be made up of very strong hands that can stand the heat. Be careful with your medium strength hands by checking them and controlling the size of the pot so you can bluff-catch more efficiently, and if you have a good but not great hand, don't be afraid of playing for stacks.

Trappy

If the limper is the trappy type and limps in with strong hands such as AK and AA with the intention of limp-raising, feel free to over-limp with all sorts of suited and connected hands and small pocket pairs. Other players at the table will hesitate to raise behind because of the threat of a limp-raise and you will be able to play very well post-flop against this face-up range.

Against this type of player, you should raise a polarized range constructed of hands that can withstand a 3-bet and hands that have good blockers and you are happy to raise-fold.

Open Push

Going all-in, also referred to as open pushing, is the most powerful bet you can make. It allows you to realize 100% of your equity with all of the hands in your range, but also involves the higher risk of putting your entire stack on the line. You can no longer fold the weaker hands in your range when your opponents would have 3-bet you if you had raised to a smaller size. In general, the more chips you have and the more players left to act, the less inclined you should be to go all-in.

Example 1

At a 9-max table with 12.5% antes and a 10bb stack, UTG can only push 14.4% hands whereas the SB can push 74.7%. This is because UTG has to worry about other eight players waking up with a strong hand while SB only has to worry about the BB.

Example 2

At a 9-max table with 12.5% antes and a 12bb stack, the BN can open push 41.5% hands but with 15bb can only open push 37.2% hands. As you risk more chips, you must raise tighter.

In general, with fewer than 10bb, players can open push from any position. The earlier your position and the larger your stack, the tighter you should push *(Table 25)*.

SB	BN	CO	HJ	LJ	UTG+2	UTG+1	UTG
25	20	15	15	15	12	12	12

Table 25: Maximum Stack Depth (bb) to Open Push by Position (MTTs 12.5% ante)

In general, when going all-in pre-flop, if you are shoving your entire range, you want your

range to be linear, consisting of the top hands that have the best equity when called.

If you are splitting your range by using a shove/raise/fold strategy, you want your open shoving range to be condensed, consisting of hands that are too good to raise/fold, while not good enough to raise/call, and will have good equity when called, like Axs, Q9s and 87s.

You want your non-all-in raising range to be polar, consisting of hands with good blocker value such as Axo that you plan to fold if your opponent pushes, and premium hands you are happy to raise/call, such as KK.

General Guidelines for Pre-flop Bet-sizing

The earlier your position, the smaller your bet-sizing should be because the threat of opponents waking up with re-raising hands increases. The wider your range becomes, the bigger your bet-sizing should be because more of your opponents' hands will have the right equity to call the same raise size vs a wider range. In general, when facing a bet or raise, the bigger the bet-size faced, the smaller number of hands you have to defend to remain unexploitable.

Multiple bet-sizes should be used only in different situations. For example, you can use different bet-sizes for the BN and UTG, or use different bet-sizes for different stack depths, but *bet-size should never be changed depending on your hand strength* because, by doing so, you convey a lot of information about your range early on, and that information can be used to exploit weaknesses in your hand distribution.

When the opponents left to act have good rejamming stack depths (under 25bb) the optimal bet-size is always a min-raise because it gives them the worst possible price on their all-in re-raise. With deeper stacks, bigger bet-sizings are better because your opponents are getting better implied odds with their speculative hands, so you want to discourage them from calling, especially when they have position.

If you are re-raising pre-flop with a polarized range, and your opponent's main response is to re-raise or fold, you should use the minimum bet-size possible to minimize your losses with the raise/folding hands in your range.

Being out of position favors larger bet-sizes because you want to decrease the positional advantage of the IP player by reducing the SPR. Conversely, having position favors the use of smaller bet-sizes because, even if called, you still have the positional advantage on the later betting rounds. However, betting small also has some disadvantages, such as giving your opponents a better price on their calls, allowing them to defend profitably with more hands.

Using solvers to test pre-flop bet-sizing, I found that for similar bet-sizes, the differences in EV are quite small and even indifferent in many situations. For example, going from a 2.25bb to

a 2.3bb open size won't have a significant EV impact in your bottom line.

The solvers are indifferent to using similar bet-sizings as long as the other player understands the best way to respond to each specific bet-size. Since different bet-sizes will have different optimal responses, and not all opponents will be capable of responding effectively to all bet-sizes, the best bet-size is the one that takes your opponents to a branch of the game tree with which they are unfamiliar, leading them to make the greatest number of mistakes.

There must be a sweet spot for pre-flop bet-sizing that lowers your risk while maximizing fold equity. However, the game of poker is not fully solved yet, so there is no definite answer to the "correct" pre-flop bet-sizing. Furthermore, there is always room for exploitative bet-sizing against specific opponents, making applying the general bet-size guidelines more of an art form than a science.

General Pre-flop Play Heuristics

You will always take the highest EV action with each hand in your range at any decision point. Note the following points.

From each position, you will play a distribution of hands that is strong relative to the random hands yet to act.

If another player has voluntarily entered the pot, your hand distribution has to be strong relative to the remaining random hands and the hand distribution of the player who entered the pot. For example, the CO raising range vs an UTG limp has to be tighter than the raising range if the action was folded to the CO because CO has to be concerned about the UTG limper.

From each position, you will play some variety of hands that will have a positive expectation against the remaining players (including the rake effect in raked games).

In general, hands that use mixed strategies (sometimes raising and sometimes folding) are threshold hands.

Given the card removal effects in Hold'em you can expect to see more hands having mixed strategies. The worst hands in your range will have zero EV and will be indifferent between raising and folding when playing against good/optimal opponents. However, you can increase your raising frequency by adding more weak hands to your range against weak opponents because they won't be playing back at you aggressively enough to make the bottom of your regular raising range indifferent.

Whenever we are exploitatively opening a wider range than usual and face a 3-bet, it's fine to over-fold.

You are exploiting the fact that you won't get 3-bet often enough by playing off-range hands. So, when you get 3-bet, your adjustment should be to fold all off-range hands and even hands that would be the bottom of your regular calling range.

The most important players to consider when deciding whether or not to open marginal hands are the BN, SB and the BB because those positions are the most likely to give you action. If the players in those positions are tight, you can get away with a lot of blind stealing.

In poker, randomizing refers to the employment of aleatoric selection between equivalent EV actions to guarantee unpredictability.

For example, if a hand is indifferent to calling or folding (the EV of both actions is the same) and the GTO solution is to call 50% and fold 50%, the player can randomize these two actions by flipping a coin. Online players can use a random number generator (e.g. random.org) to help them stay unpredictable with hands that have mixed strategies.

Live players can use a number of randomizers such as the seconds hand on a clock or the suit of their hole cards. For example, the probability of the top card of a two-card hand being a red card is 50%, so a player can randomize using the color of the top card of their poker hand. Players can also choose a suit such as hearts, and if their first card is a heart, choose various 25% plays. They can also simply look at a random number generator app before starting each hand. There are many tricks players can use to randomize their actions in live games. However, live games are often particularly soft, so wise decisions tend to be more binary, and there are regularly additional pieces of information players can use to tie-break close decisions, such as body language, history, population tendencies, etc. All of this, along with the fact that it will be tough for your opponents to get a large enough sample on you to be able to unravel your exact frequencies makes randomizing less needed in live poker than online poker.

The best approach when exploitatively widening your ranges is to start by increasing the frequency of hands that are played with a mixed strategy.

This is because the threshold hands are the first hands to become profitable against Villain leaks. For example, if a hand such as A9o is bet 25% of the time in some spot, the best exploit against a player who overfolds will be to bet A9o 100% of the time. From there, you can add hands that are very close to the borderline hands, such as perhaps A8o and A7o, instead of randomly adding something like Q4o. This type of adjustment is more difficult to spot by the Villain, decreasing the likelihood of them counter-exploiting you, and when you do get counter-exploited or are

wrong about your assessment of the Villain's leak, the hands you are adding to your strategy will have the right blockers, meaning they won't be as -EV as random hands.

Avoid putting yourself in difficult spots by always thinking a few steps ahead.
For example, if you are thinking about 3-betting with a medium strength hand but would not know what to do if your opponent re-raises, you should call instead. This also applies post-flop. If you don't know what to do with your hand if your opponent re-raises, then check instead. Before open raising, always consider the players yet to act. Are they likely to re-raise you? If so, how would you react against a re-raise? And what if they 5-bet after you 4-bet? Are you happy getting this hand all-in pre-flop? Is your hand too good to 4-bet/fold? If so, just call if you get 3-bet. Thinking ahead will allow you to sidestep many difficult spots recreational players find themselves in on a regular basis.

> *Poker players tend to have two main types of leak. Either their action frequencies are wrong, or they put the wrong type of hands in their ranges.*

Typically, the first and easiest leak to fix is when your frequencies are wrong, which is particularly true when playing online poker. Most online regulars will have a HUD (Heads Up Display) that shows the frequency with which players take different actions. In this case it becomes very evident when their tendencies are far away from optimal.

For example, if you know that the optimal RFI frequency from the LJ in a cash game is ~17% and you notice you are opening 22%, then you should cut down the extra 5% of hands from your range if you think you are being exploited by your opponents.

The other type of leak is a lot harder to spot, as a player could have very well been taking actions with the right frequencies, but putting the wrong hands in their range. This is the main reasons most regulars struggle to move up in stakes. More often than not they don't even know where to start looking. They understand their own and their opponents stats, and they have a general idea of what the ranges look like but they also notice the top players shifting gears and showing up all the time with stuff they didn't expect them to have. They ask their coaches and friends and they all seem to have different answers to the same questions.

In the next chapter I aim to show you not only the right frequencies but also the right range composition, so you can estimate by yourself how to adapt to the different situations at the poker table, think on your feet, attack your opponent's leaks and fix your own.

6-MAX CASH GAME EQUILIBRIUM STRATEGIES (100BB)

This chapter presents GTO recommended 6-max baseline strategies produced with modern solvers and supercomputers for a typical $2/$5 online cash game, 5% rake, capped at $3. These strategies are designed to be a solid guideline but they must be adjusted to the specific games you find yourself in.

The best use for GTO solvers is to analyze the recommended strategies and try to understand why the solver is choosing to play hands in the way it does, incorporating the underlying GTO principles such as pot odds, equity, fold equity, EV, equity realization, SPR, range polarization, board coverage, MDF, exploitation and balance to our decision-making process instead of trying to memorize fixed strategies.

> *In some sense, you should try to "become" the solver so you can determine the correct decision for yourself. Each hand is a puzzle, and solving that puzzle to the best of your ability is your job as a poker player.*

Charts are a good starting point. They can be used to guide you in the right direction but should never be followed blindly.

Recommended Bet-sizings

This section presents bet-sizes based on the previously discussed principles, extensive testing with pre-flop GTO solvers and discussions with world class players. In live cash games, bet-sizes tend to be a lot bigger than online, but live cash games also tend to be played with deeper stacks, which will generate similar post-flop SPRs. Following are the recommended sizings.

Heads-up

BN RFI: 2.5bb, BB 3-bet: 10bb, BN 4-bet: 23bb, BB 5-bet: All-in (100bb).

6-Max

RFI: LJ, HJ, CO, BN: 2.5bb, SB: 3bb.
3-bet: IP: 8.5bb, OOP: 10bb (when squeezing you can add 2-3bb)
4-bet: 23bb
5-bet: All-in (100bb)

BvB

SB Limp:
BB Raise vs SB Limp: 3.5bb
SB 3-bet: 13bb
BB 4-bet: 28bb
SB 5-bet: All-in (100bb)
SB Raise:
SB: 3bb
BB 3-bet: 9bb
SB 4-bet: 24bb
BB 5-bet: All-in (100bb)

GTO Raise First In Strategies

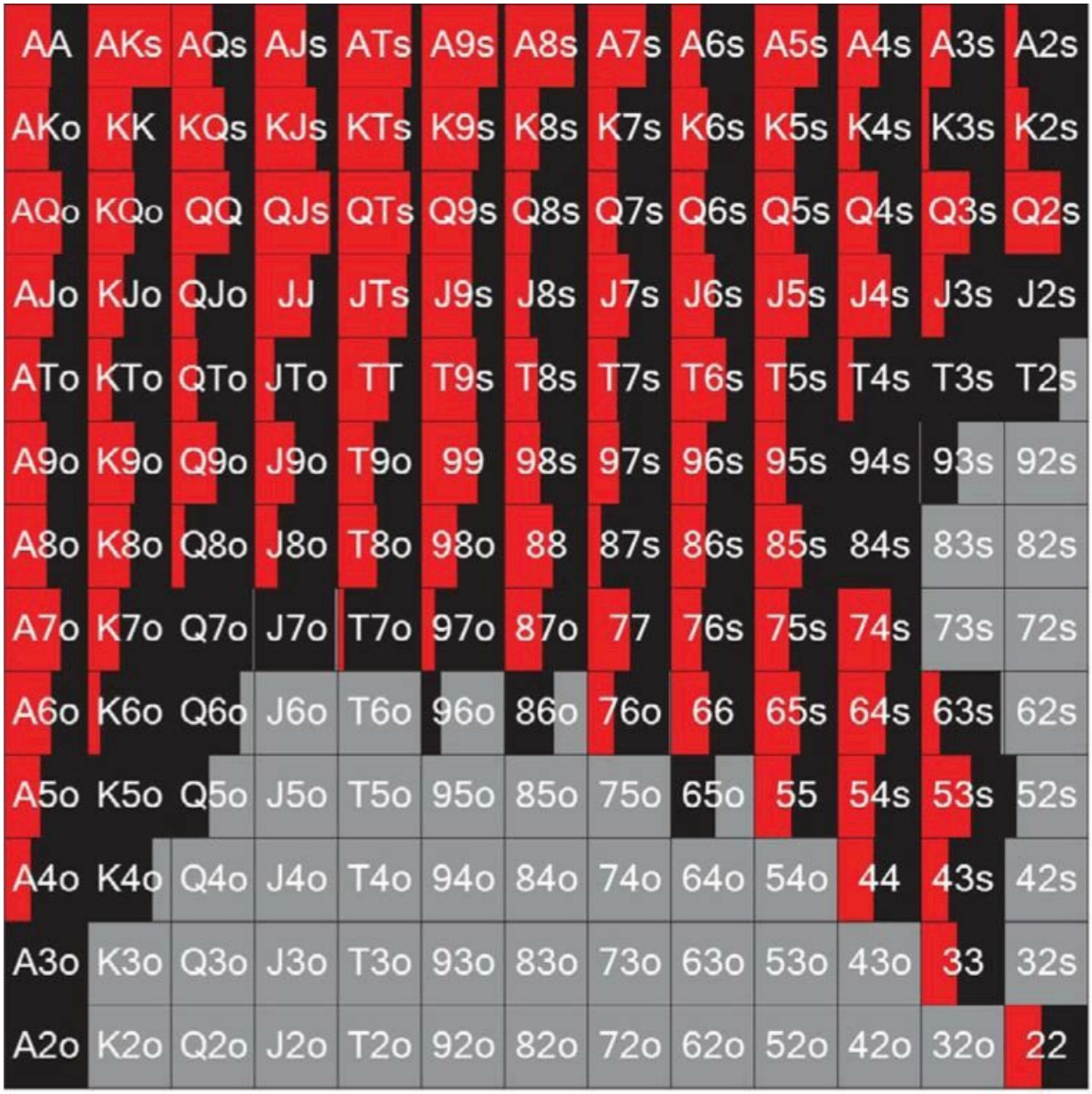
We will start the pre-flop analysis with the simplest possible scenario, blind vs blind battles. We will then expand the strategies by incorporating BN, CO, HJ, and finally LJ. It is important to note that these baseline strategies are computed using the recommended bet-sizes, so adjustments have to be made when facing different bet-sizes.

Small Blind

The small blind is one of the most interesting and difficult positions to play. You will be out of position the entire hand, which reduces your ability to realize equity and makes playing less enticing. However, you also have a discount in your price to enter the pot, which incentivizes you to play more hands.

The best approach to SB play when the action gets folded to you is to split your range, developing a limping strategy and a raising strategy *(Hand Range 32)*. By incorporating a

limping strategy, you get to play more hands, taking advantage of the discount to enter the pot while keeping your overall raise frequency low, making BB's 3-bets less effective. Also, the SB is the position where you want to have a bigger open raise size because you are out of position and want to discourage calls.



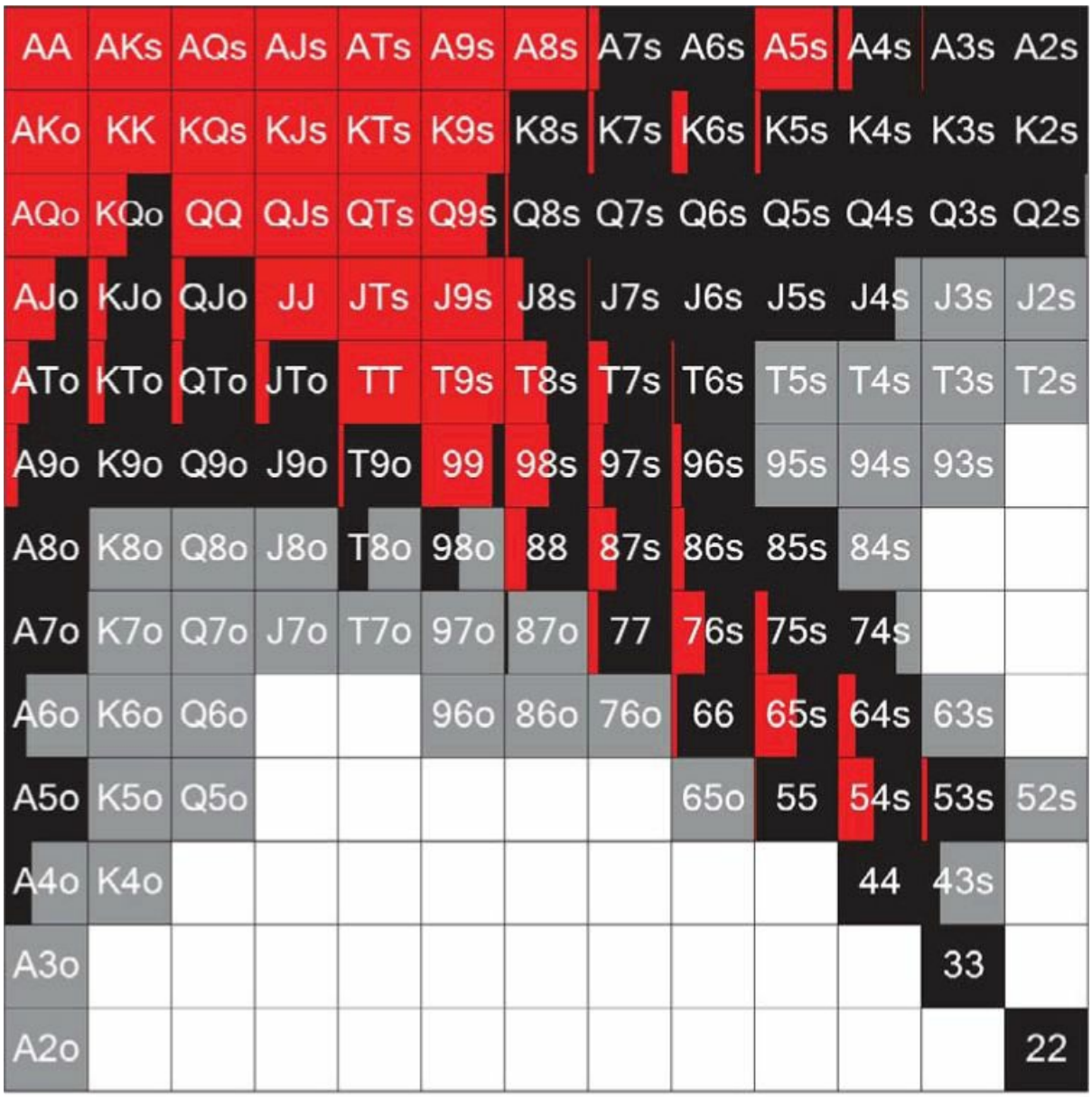
Hand Range 32: SB RFI

• 3x 24.4% / • Limp 37.7% / • Fold 37.9%

After SB limps and BB raises to 3.5x, the SB wants to re-raise a linear range made of high equity hands, so if you get 4-bet, you can call and have hands that will have better equity

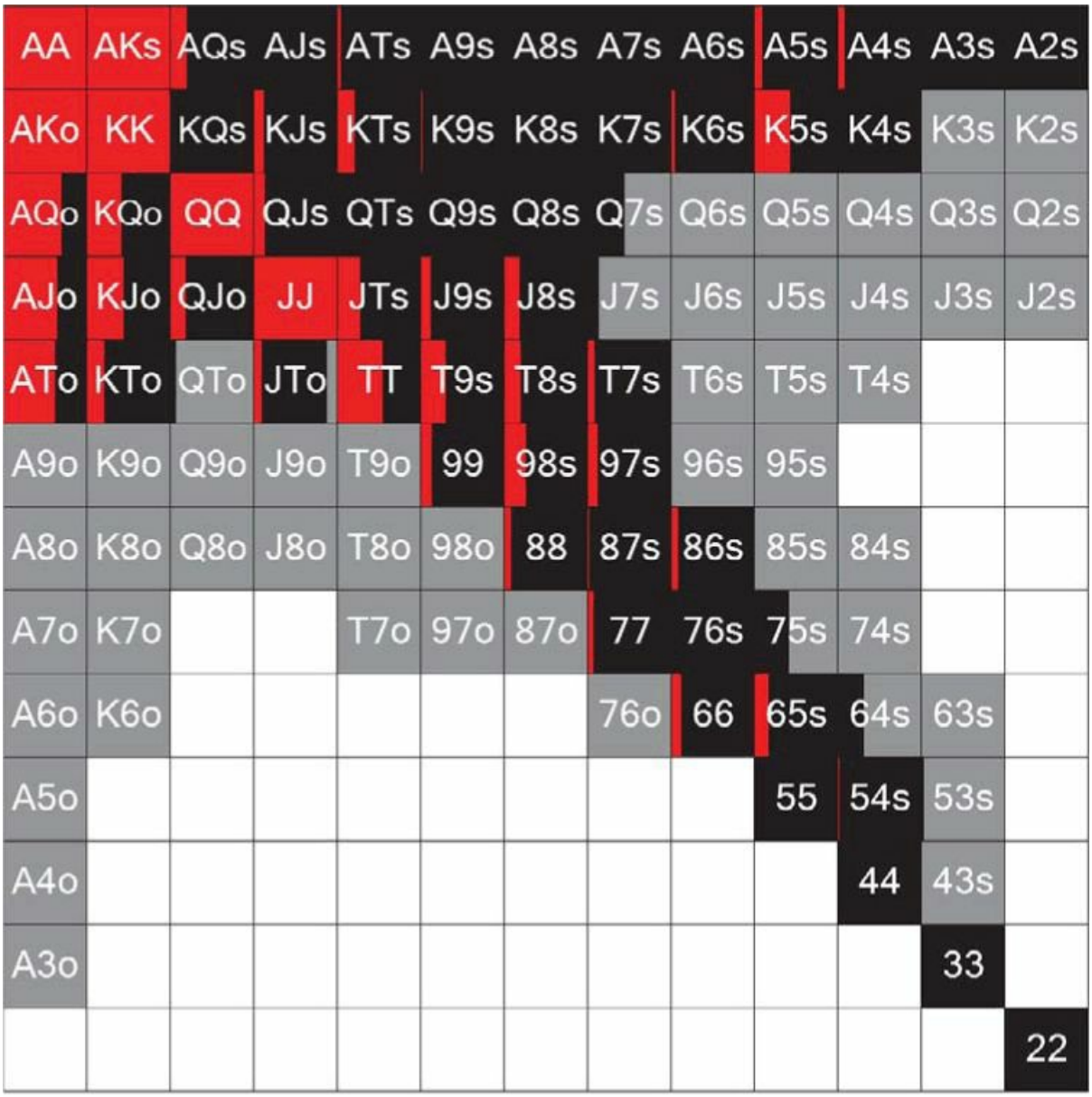
realization in low SPRs. Against a 4-bet, you slowplay AA by calling (98%), and 5-bet push KK (100%), QQ (100%), AK (100%), JJ (32%), TT (64%), 99 (6%) and A5s (78%) *(Hand Range 33)*.

After you raise to 3x from the SB and face a BB 3-bet, most of your middle strength hands really hate to 4-bet/fold vs an all-in and just want to take a flop. Therefore your 4-bet range is polarized, consisting of hands with good blockers that are happy to either call or fold vs a 5-bet push while having good board coverage in case Villain decides to flat the 4-bet *(Hand Range 34)*. Your stacking off range vs a 5-bet push is 66+, AKo, AQs+.



Hand Range 33: SB Limp vs BB 3.5x Iso Raise

• L/R 13.4% / • Call 39.8% / • Fold 46.8%

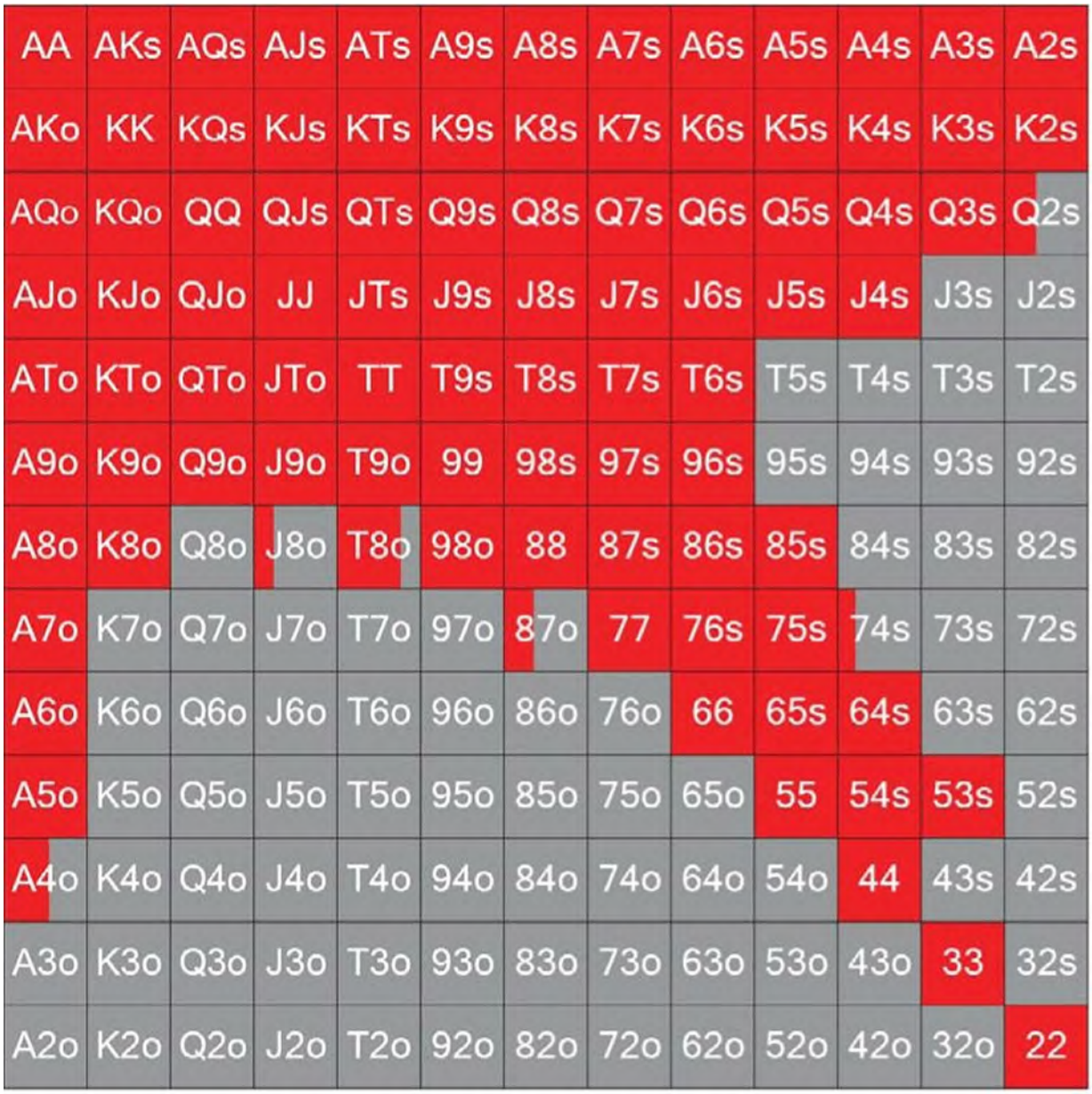


Hand Range 34: SB 3x Raise vs BB 3-bet

• 4-bet 17.2% / • Call 37.4% / • Fold 45.4%

Button

When the action folds to you on the BN, you play a raise or fold strategy *(Hand Range 35)*.



Hand Range 35: BN RFI

• Raise 2.5x: 43.4% / • Fold 56.6%

As explained before, the rake makes open limping a lot less profitable in cash games and, unlike the SB, the other positions don't get a discount on their limps. By limping from other positions, you encourage other players to enter the pot which is not a desirable outcome because, in multi-way pots, the pot will be split among more players. Furthermore, the likelihood of other players raising over your limps increases with the number of players left to act. Therefore limping from any position other than the SB involves a higher risk of getting raised, which will either force you to put more money into the pot or fold your hand, thus denying your equity. By

playing a raise or fold strategy, you make sure your range is well protected and can be easily defended against 3-bets.

When the action folds to you in the SB, you get to play 62.21% hands. However, unlike the SB, you don't get a discount to play your hands and you now have to worry about two players who might have a re-raising hand. Even with your positional advantage over the blinds, the BN equilibrium strategy is to open a maximum of 43.4% of hands including all pairs, A2s+, A4o+, K2s+, Q2s+, J4s+, K8o+, Q9o+, J8o+, T8o+, 98o+, suited connectors and suited gappers. In soft games, if the blinds are overfolding vs opens, the raising range can be easily expanded to 55-60% hands, or even more, depending on how bad and passive the blinds are.

The BN defense strategy against both blinds is very similar *(see Diagram 7 and Hand Ranges 36 and 37)*. You fold a little less against a SB 3-bet because the pot is slightly bigger when SB 3-bets (27bb) compared to when BB 3-bets (26bb). Since you have position and the blinds can put in the last bet if you 4-bet them (forcing you to fold your equity) you do better having a polarized 4-betting range consisting of hands with good blockers and reasonable board coverage. If you get 5-bet, your getting in range is 66+, AK+ (it's important to notice how hands such as 66 are present in your 4-bet range with a very small frequency at this point, but they are getting in when you do have them).

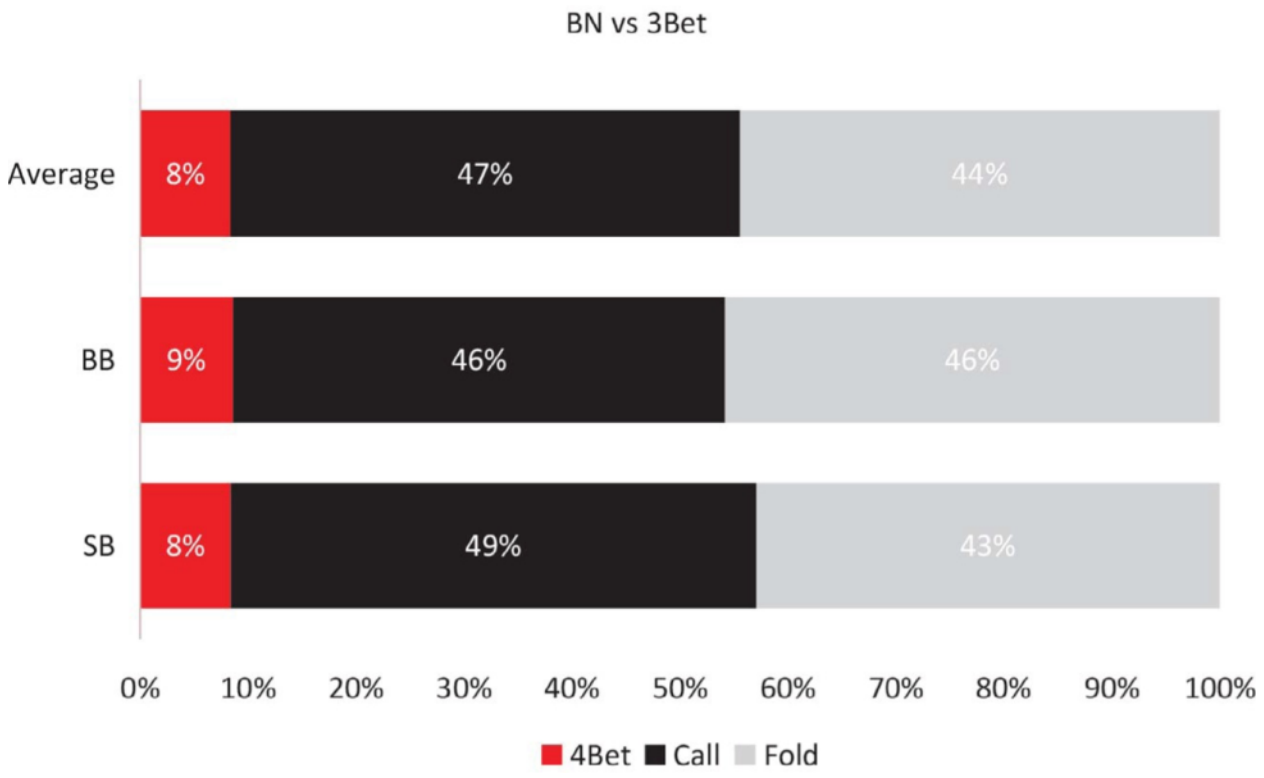
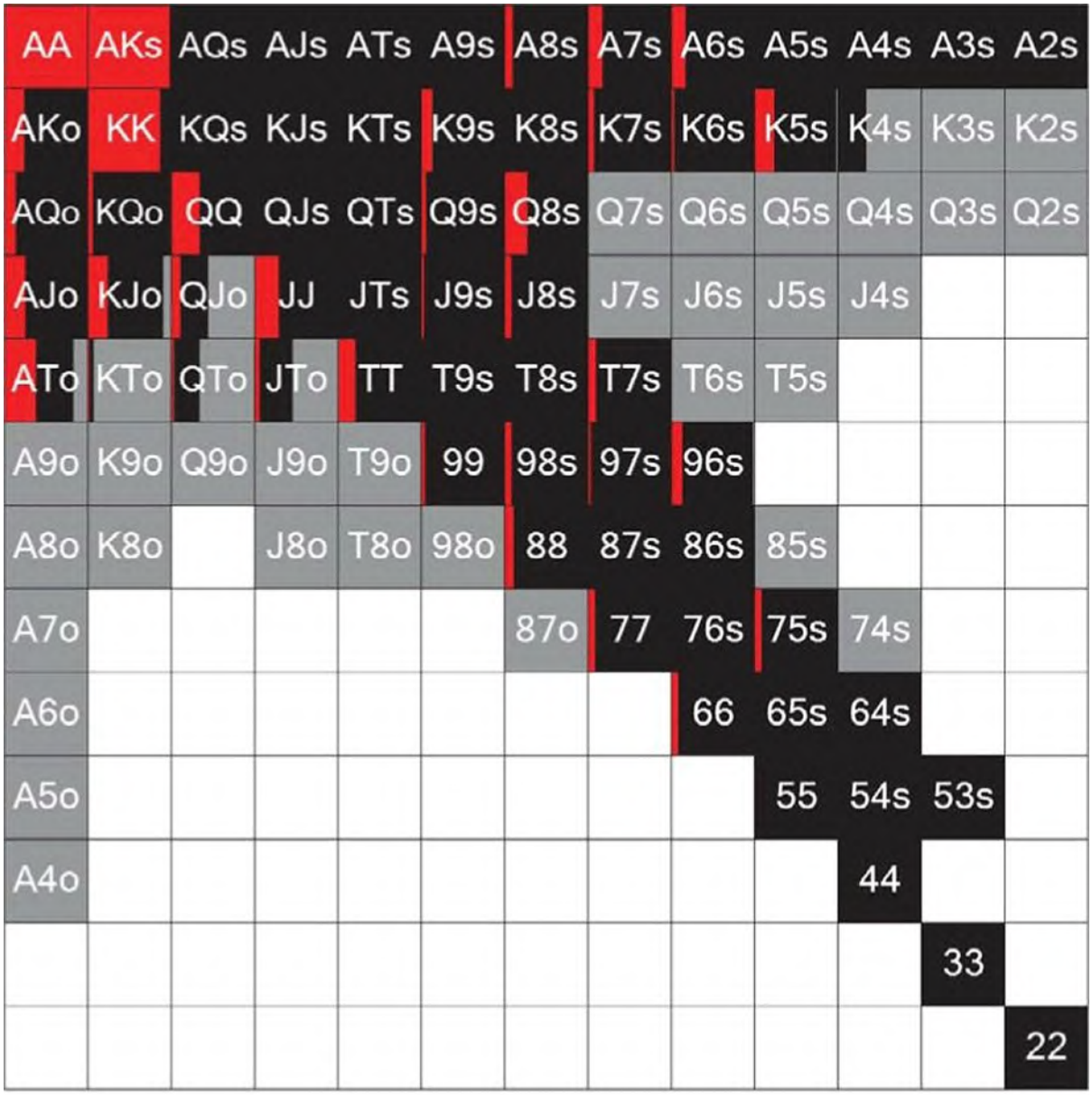
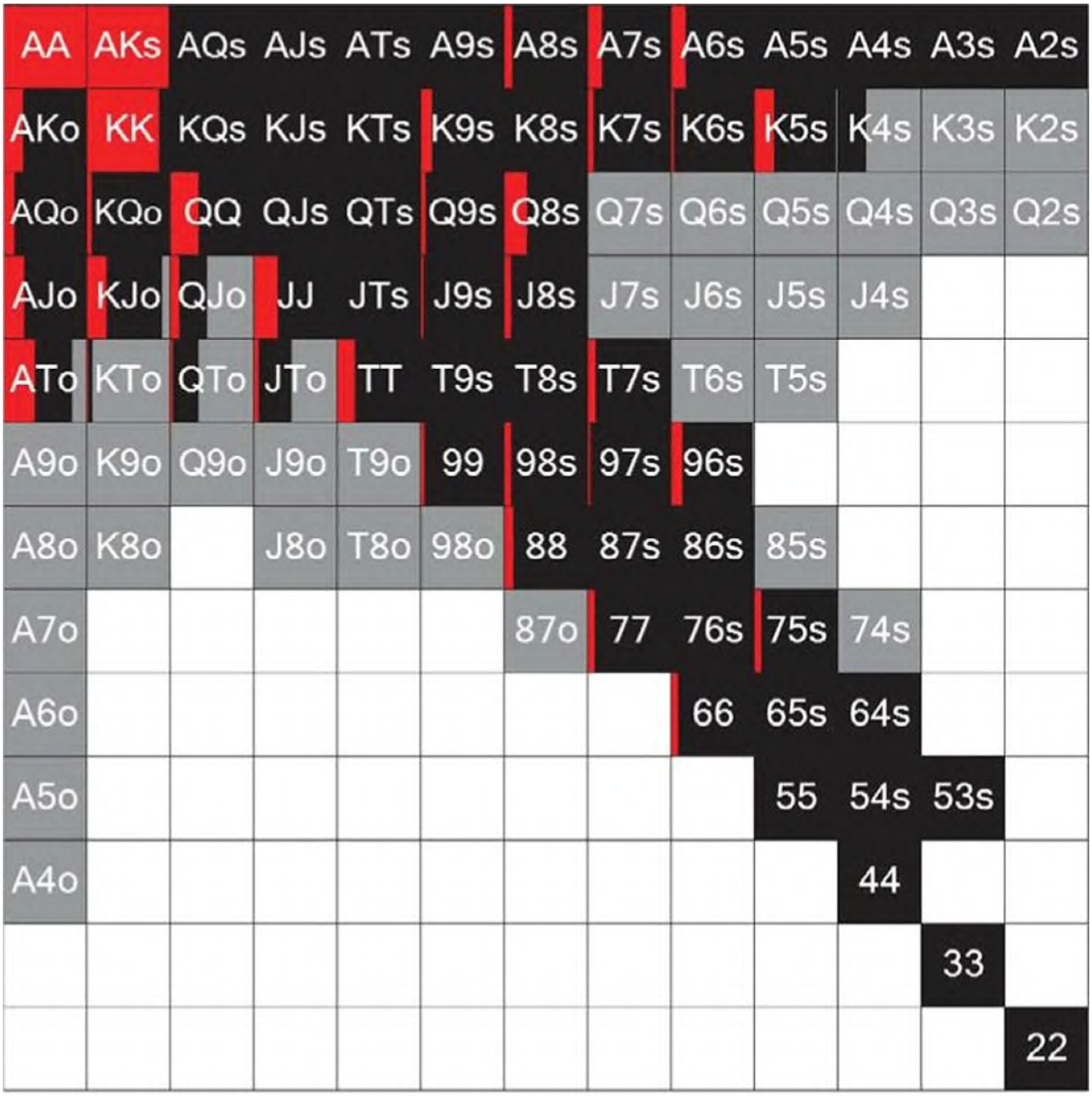


Diagram 7: BN Response to 3-bet from the Blinds



Hand Range 36: BN vs SB 3-bet

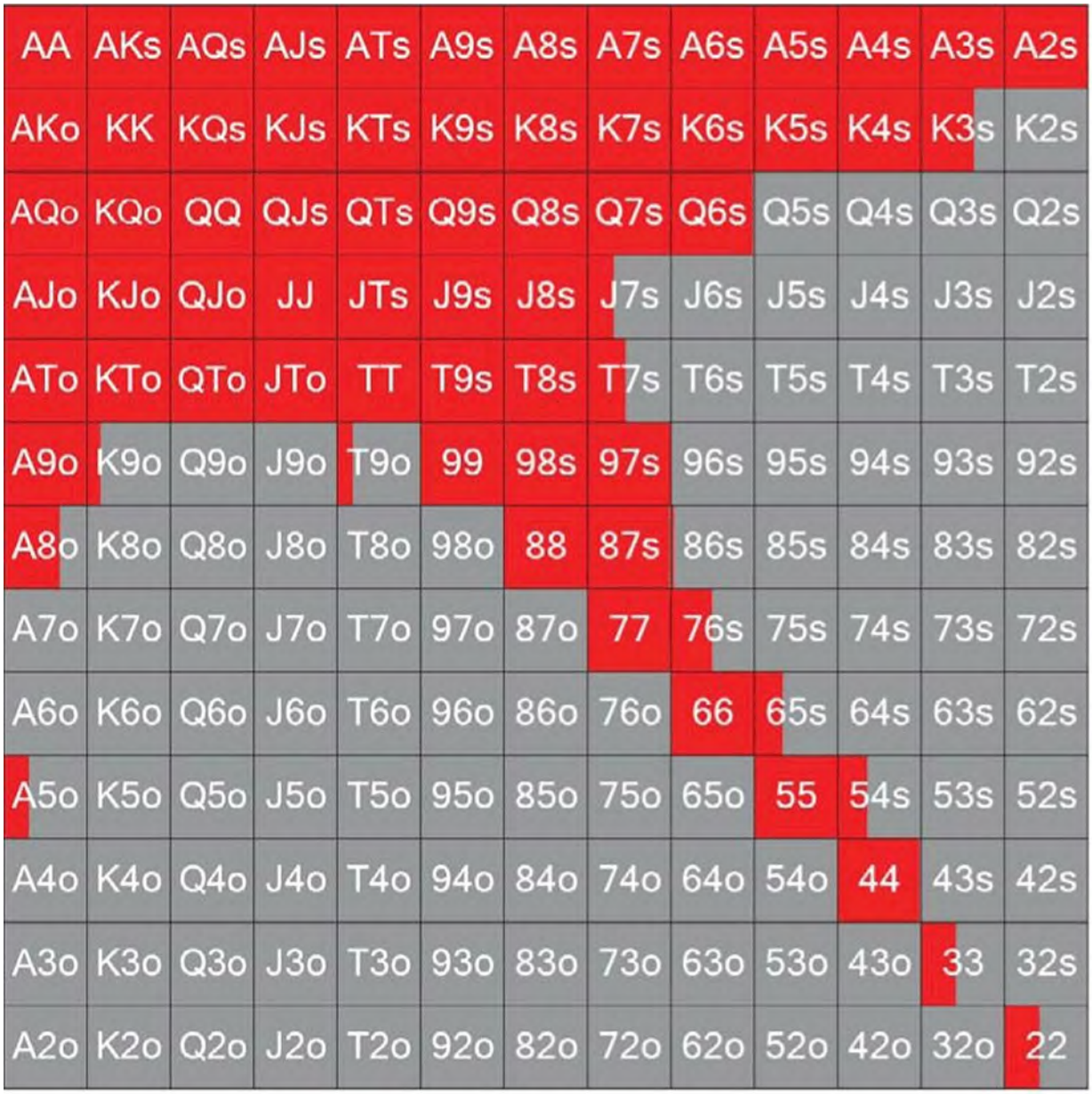
• 4-bet 8.1% / • Call 48.9% / • Fold 43.1%



Hand Range 37: BN vs BB 3-bet
• 4-bet 8.6% / • Call 47.3% / • Fold 44.5%

Cutoff

While the CO position may seem similar to the BN, it actually plays quite differently. You now have to worry not only about the blinds, but also the BN who has position on you and can call or 3-bet as they see fit. So, the total hands you can play from the CO gets reduced to 27.8%. From the CO, hands such as K2s, Q5s-Q2s, J6s-J4s, A7o-A2o, offsuit connectors and suited gappers are not strong enough to enter the pot *(Hand Range 38)*.



Hand Range 38: CO RFI

• Raise 2.5x: 27.8% / • Fold 72.2%

When facing 3-bets, if you have position, your strategy involves mostly calling, leaving your 4-betting range very polarized *(Diagram 8)*. However, vs the BN, you are much more incentivized to 4-bet and try to either take the pot pre-flop or force a low post-flop SPR to reduce the BN's positional advantage *(Hand Range 39)*. Playing out of position post-flop makes realizing your hand's equity much more difficult, so you are forced to call less and fold more against the BN than against the blinds *(Hand Ranges 40 and 41)*.

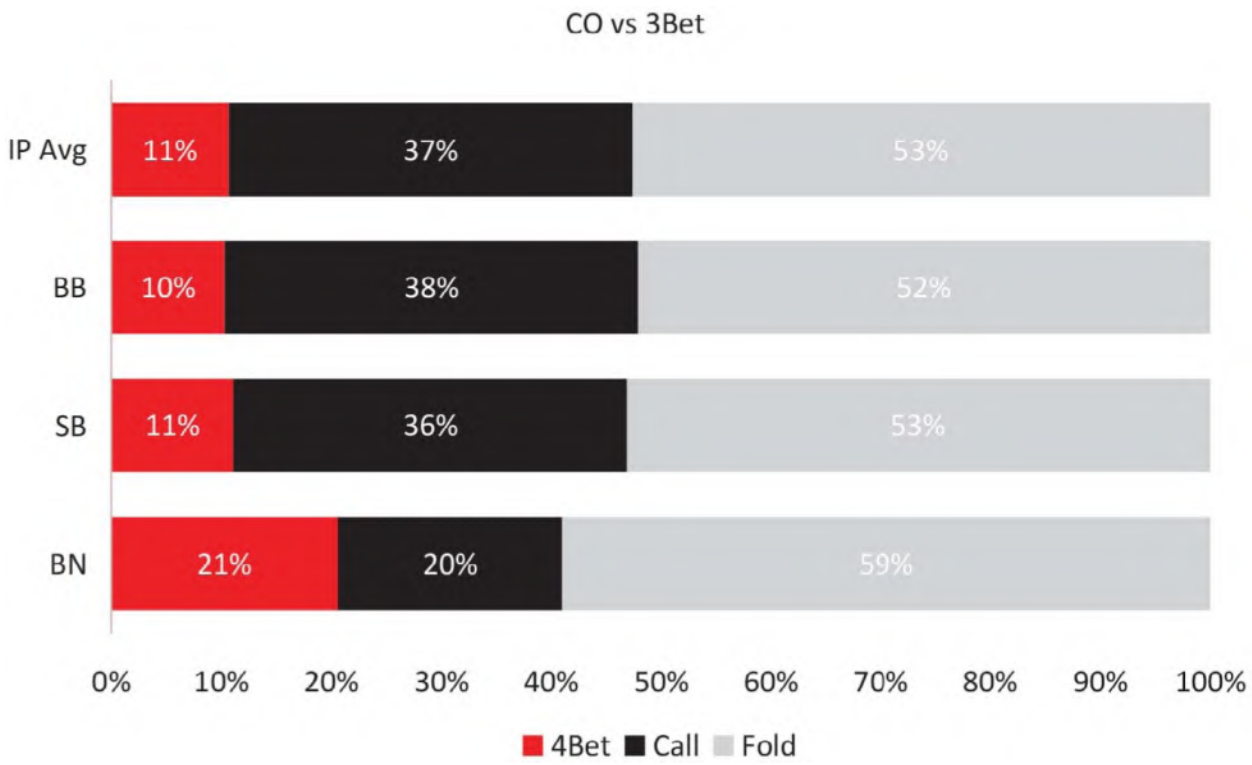
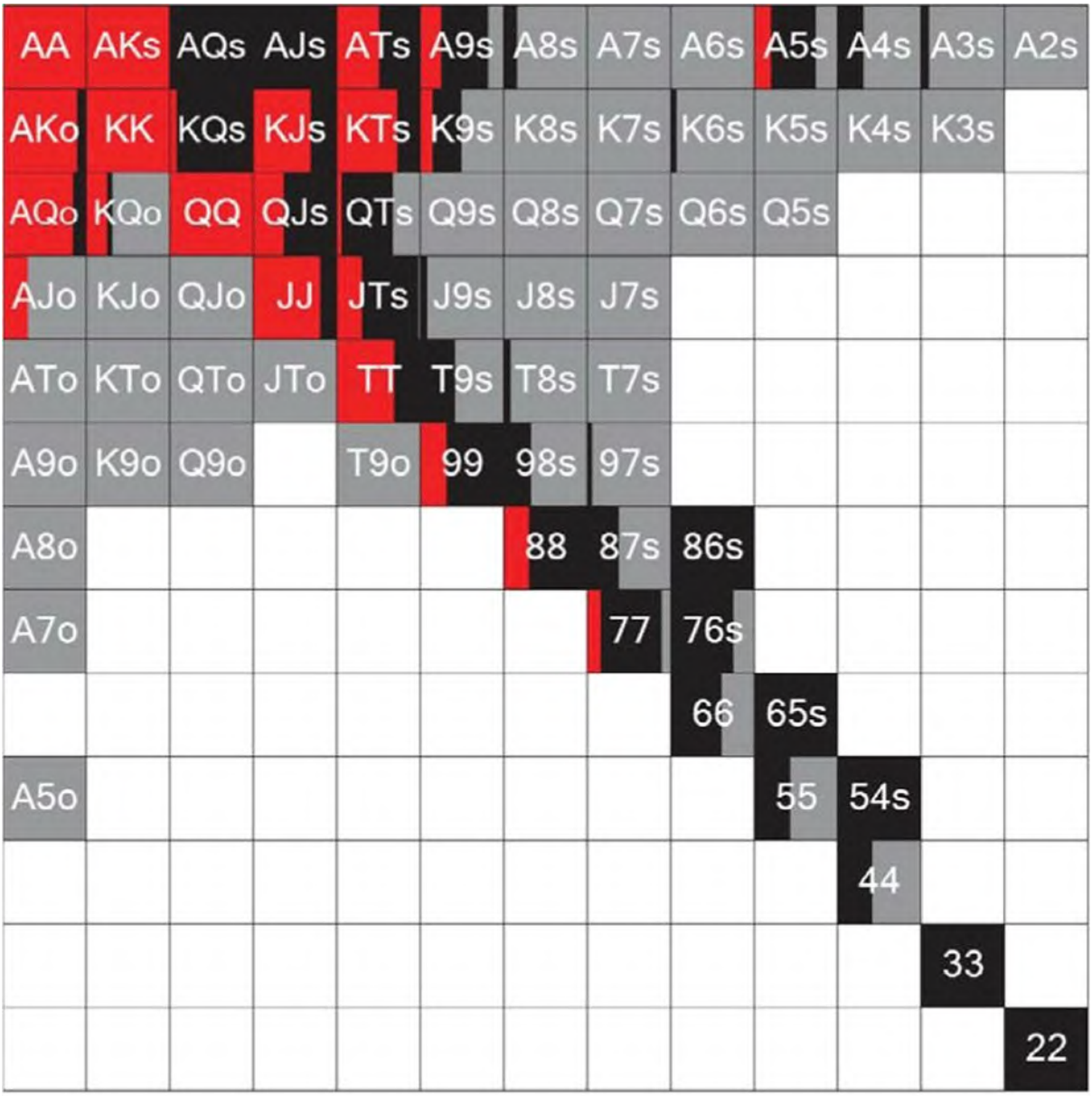
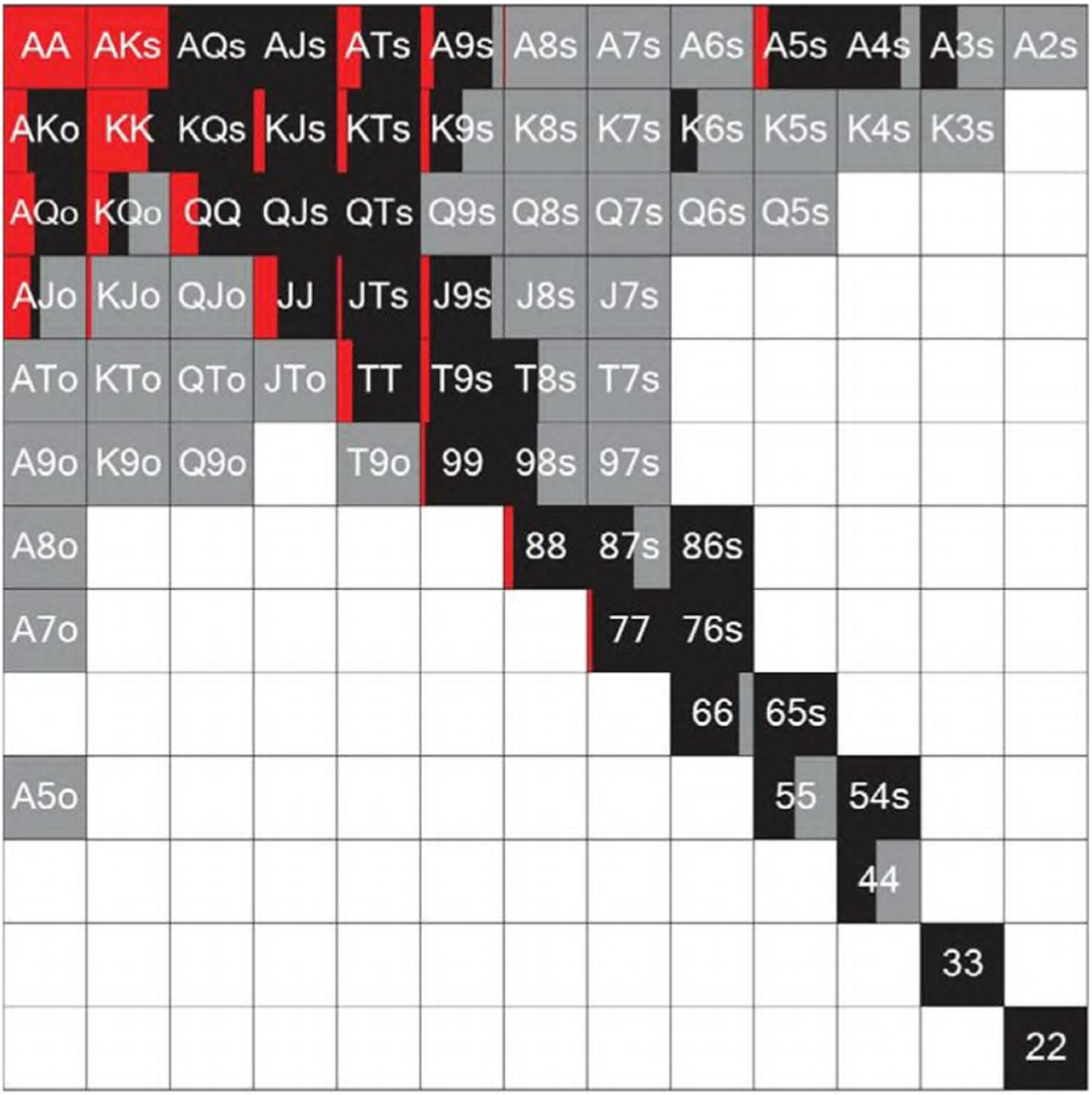


Diagram 8: CO Response to 3-bets



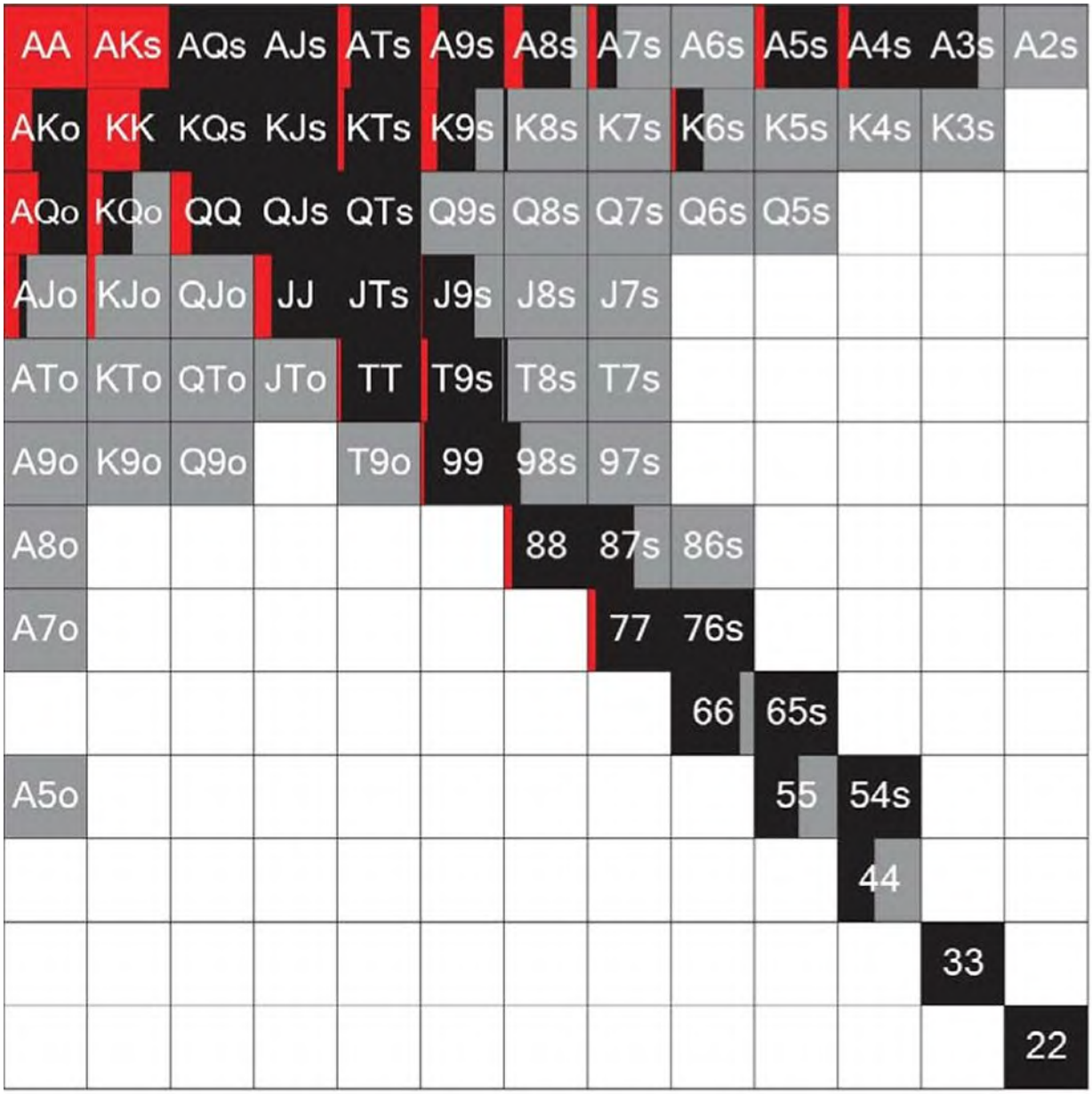
Hand Range 39: CO vs BN 3-bet

• 4-bet 20.6% / • Call 20.4% / • Fold 59%



Hand Range 40: CO vs SB 3-bet

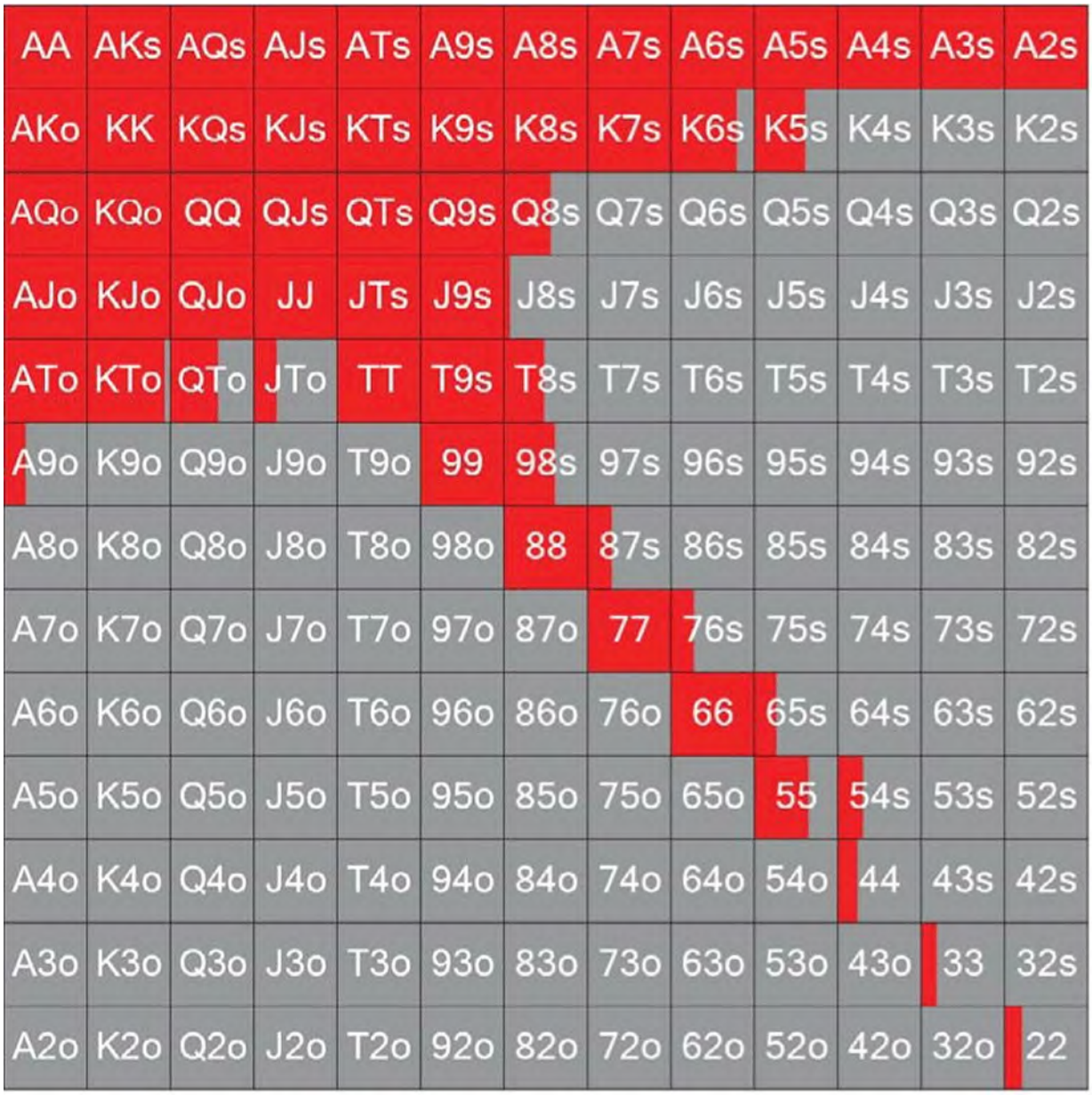
• 4-bet 11.1% / • Call 35.8% / • Fold 53.1%



Hand Range 41: CO vs BB 3-bet
• 4-bet 10.3% / • Call 37.6% / • Fold 52.1%

Hijack

From the HJ you have to worry about four players still to act and two of them have position, which will limit your ability to play many hands profitably. The total hands you can play at equilibrium is reduced to 21.4%, trimming down on smaller pairs, the worst offsuit broadways, suited connectors and weak suited Kx and Qx *(Hand Range 42)*.



Hand Range 42: HJ RFI
• Raise 2.5x: 21.4% / • Fold 78.6%

On average, you fold a lot less against 3-bets when you have position, defending mostly by calling against the blinds and 4-betting more often when out of position. Also, you get to call with a wider range against BN 3-bets than against the CO because the BN has a flat calling range, so their 3-betting range is a lot more polarized than the CO *(Table 26 and Diagram 9)*. In general, opening ranges have better equity and playability against polarized ranges, making more hands profitable calls.

Versus	HJ Range vs Range EQ
CO 3-betting range	42.94%
BN 3-betting range	44.75%

Table 26: HJ Equities vs 3-bet Ranges

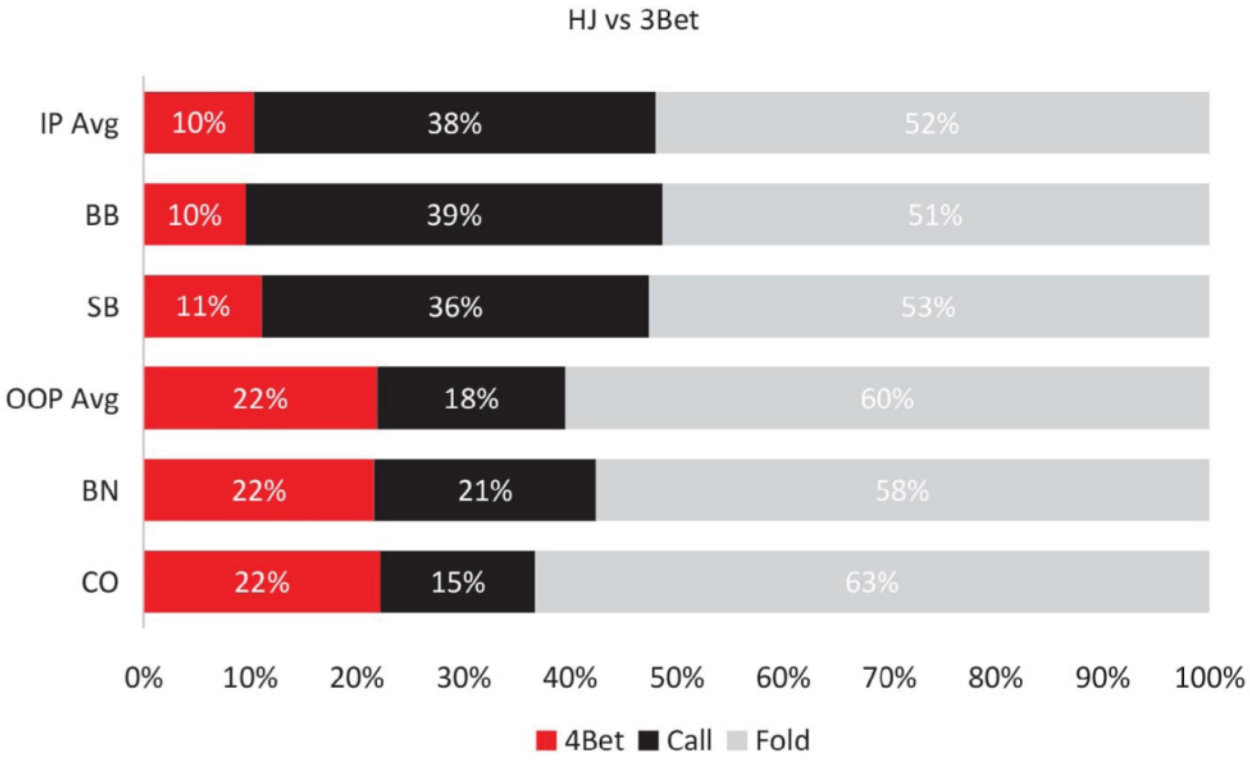
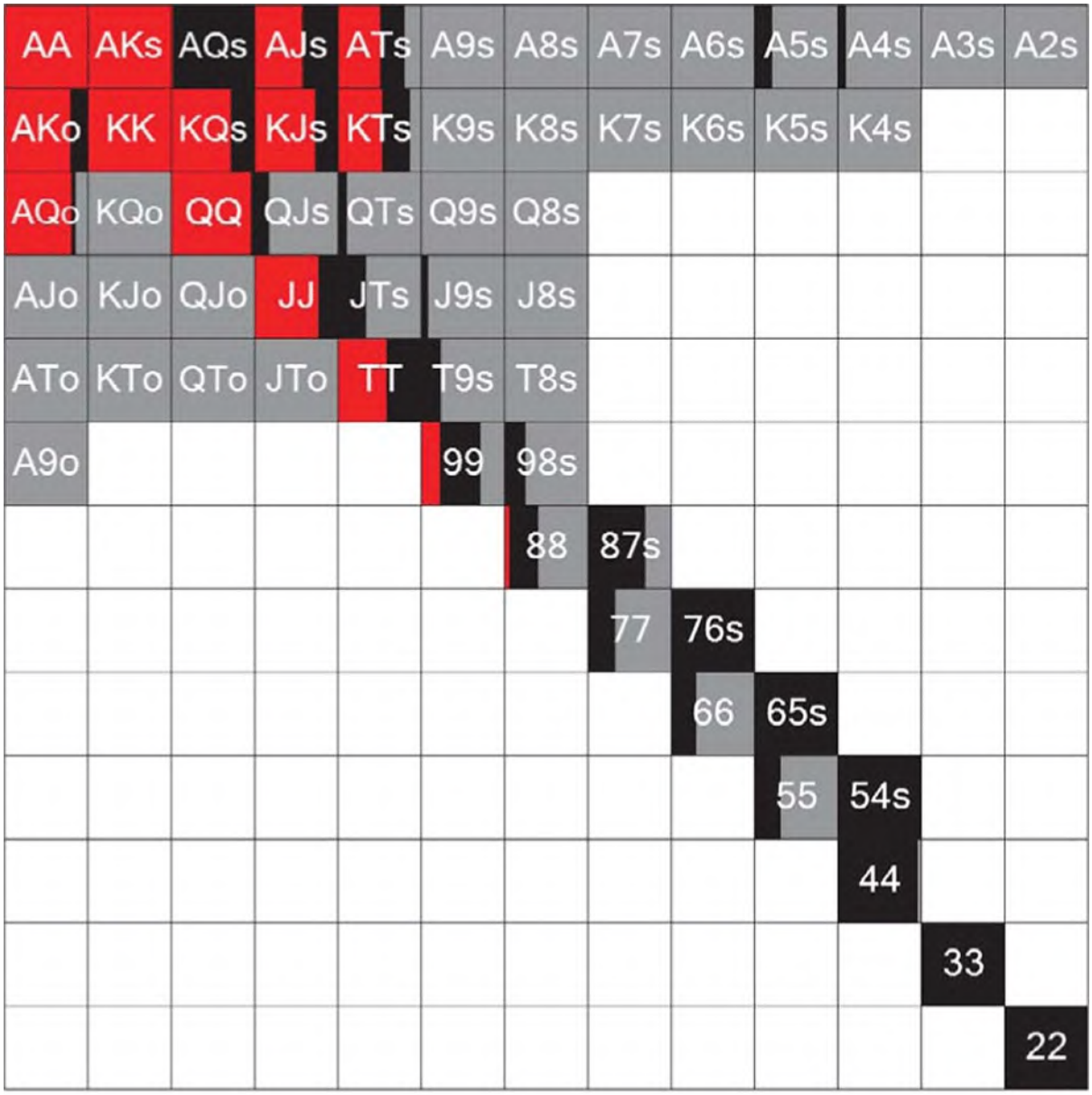


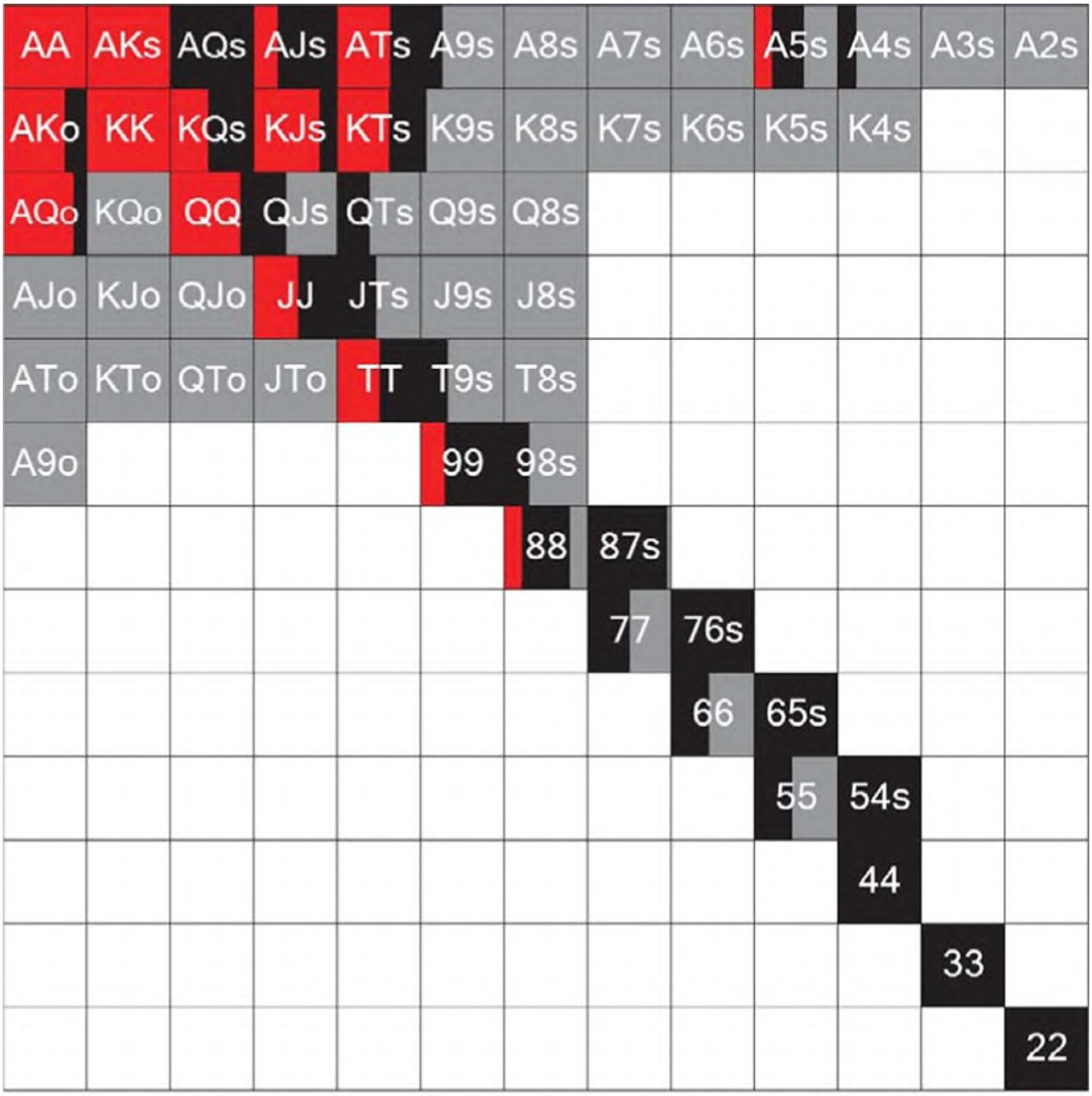
Diagram 9: HJ Response to 3-bets

The HJ response to 3-bets is seen in *Hand Ranges 43-46*.



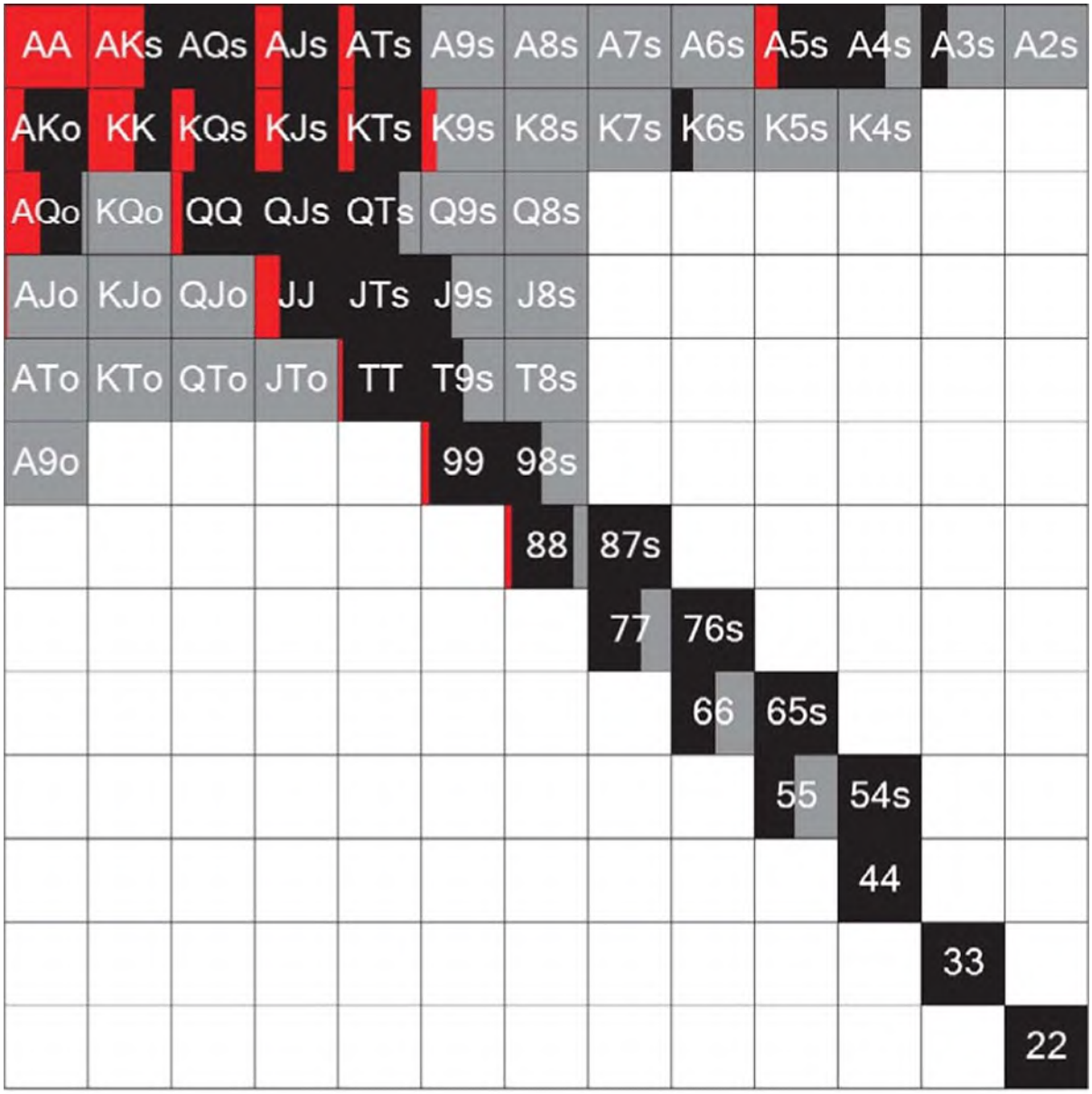
Hand Range 43: HJ vs CO 3-bet

• 4-bet 22.2% / • Call 14.5% / • Fold 63.3%



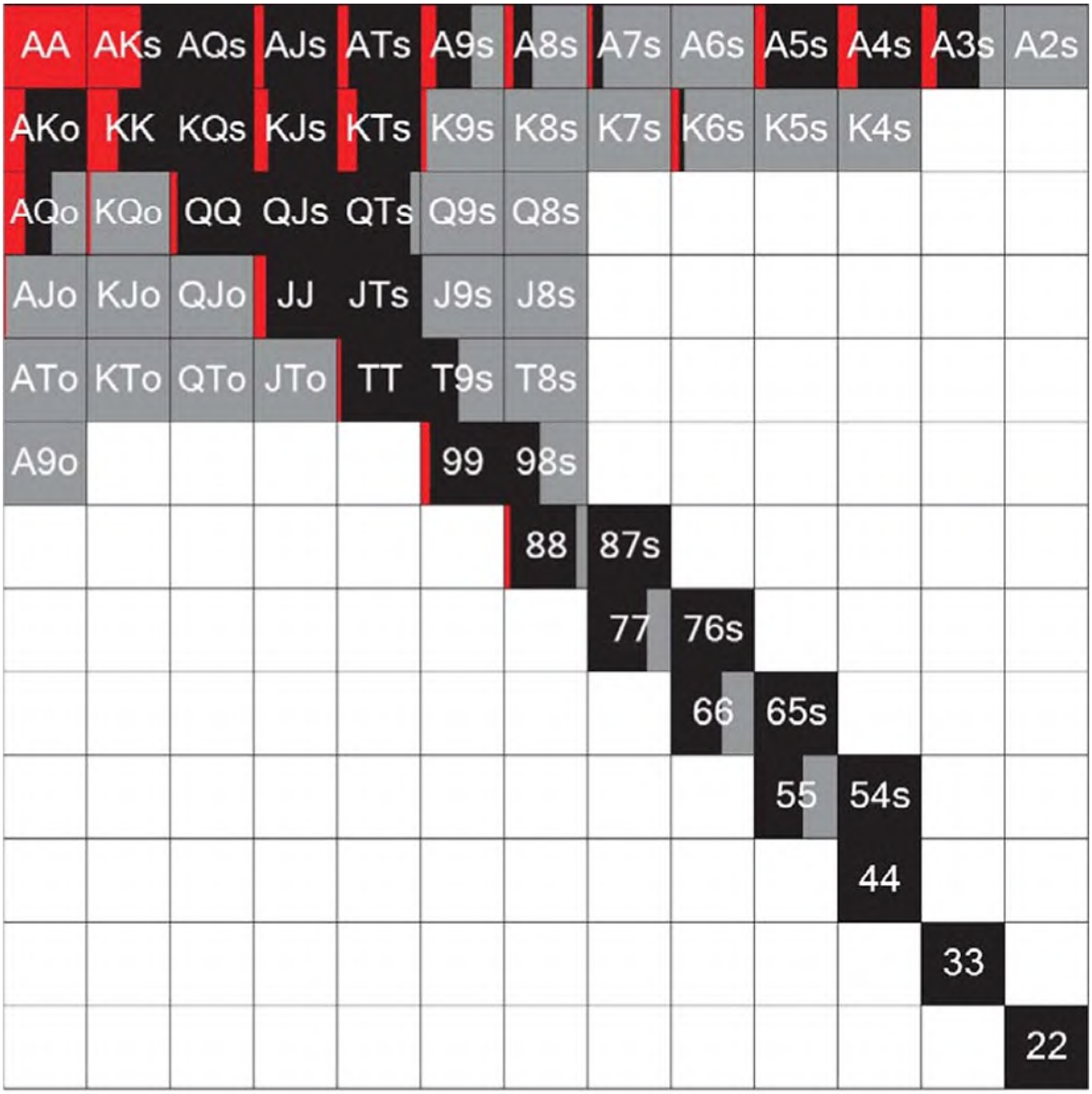
Hand Range 44: HJ vs BN 3-bet

• 4-bet 21.6% / • Call 20.8% / • Fold 57.6%



Hand Range 45: HJ vs SB 3-bet

• 4-bet 11.1% / • Call 36.3% / • Fold 52.6%

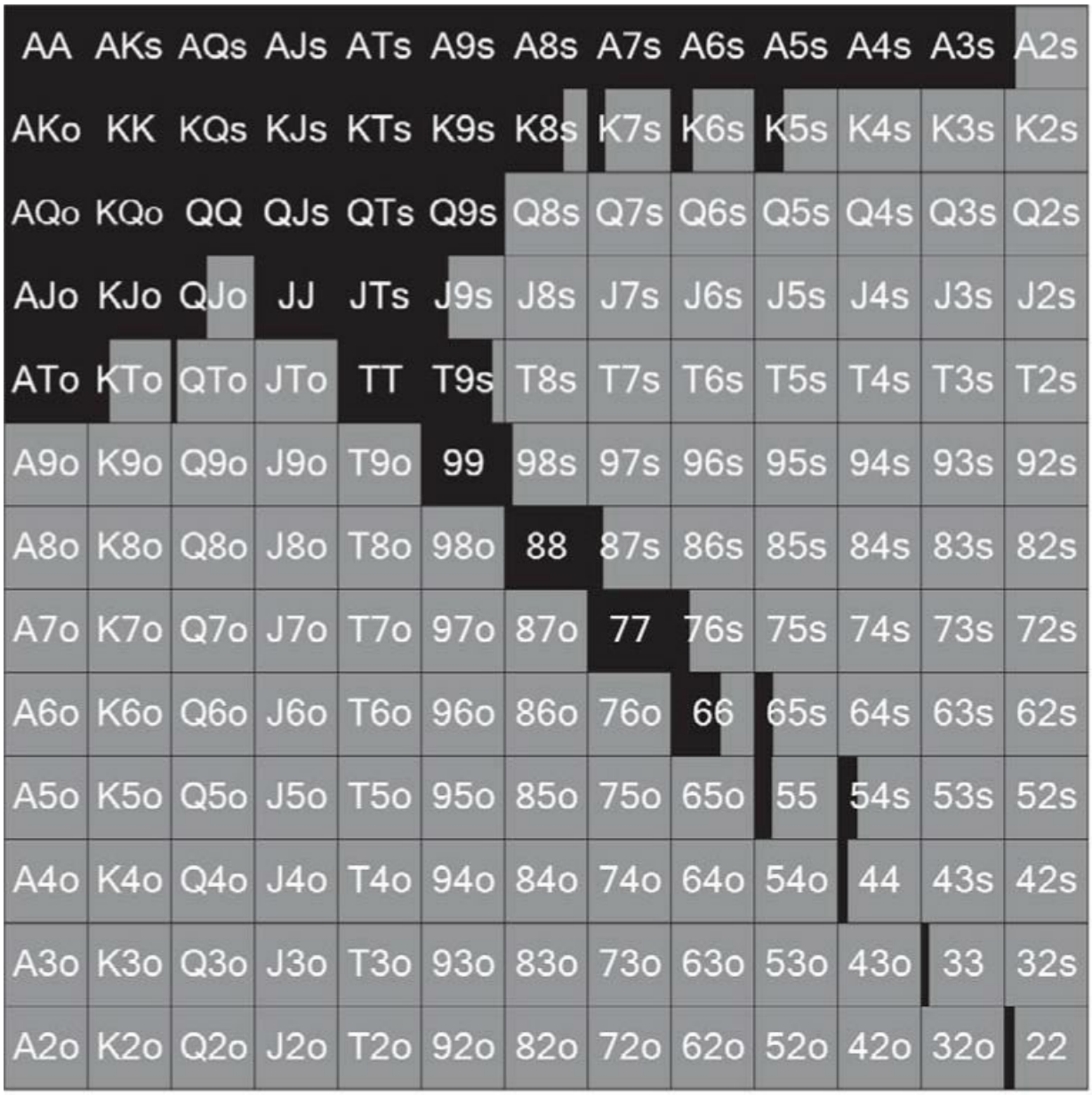


Hand Range 46: HJ vs BB 3-bet
• 4-bet 9.6% / • Call 39.1% / • Fold 51.4%

Lojack

The LJ is the position where you start having to be much more careful, playing only 17.1% hands. If you decide to enter the pot, you have to take on five other players who can play back at you and three of them have position, hindering your ability to realize equity. You mostly get to play high equity hands with really good blockers and a small portion of suited connectors and small pairs for the purposes of board coverage *(Hand Range 47)*.

The LJ response to 3-bets is seen in *Diagram 10* and *Hand Ranges 48*-*52*.



Hand Range 47: LJ RFI

• Raise 2.5x 17.1% / • Fold 82.9%

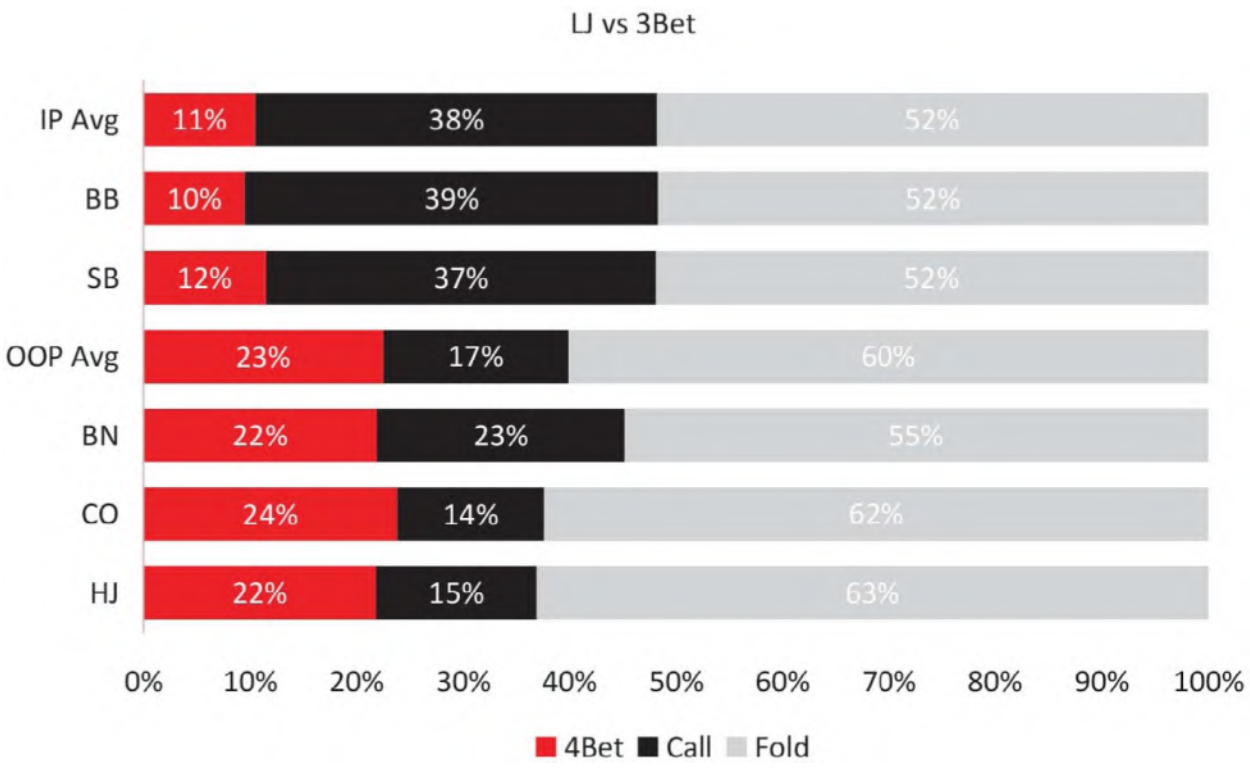
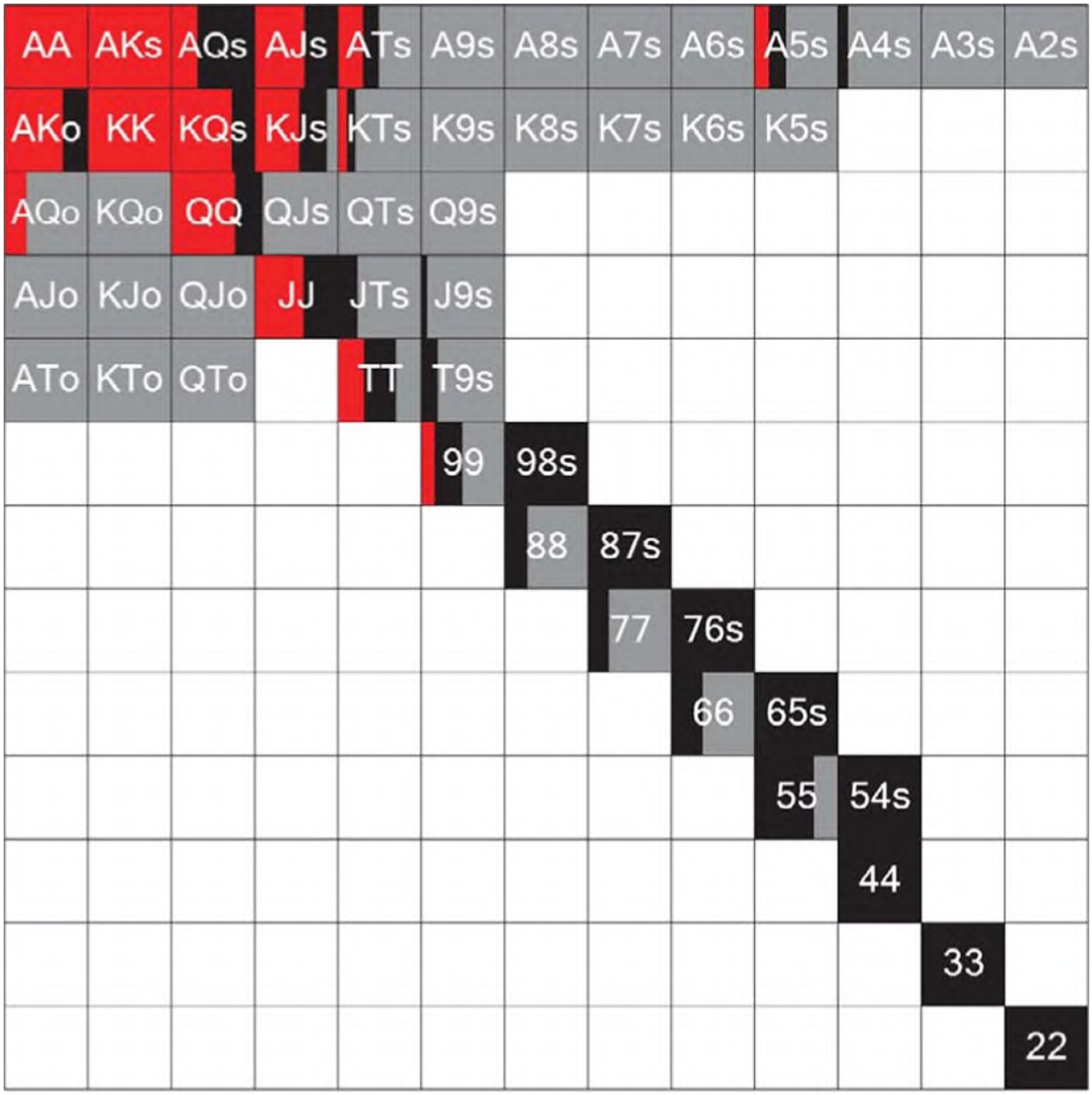
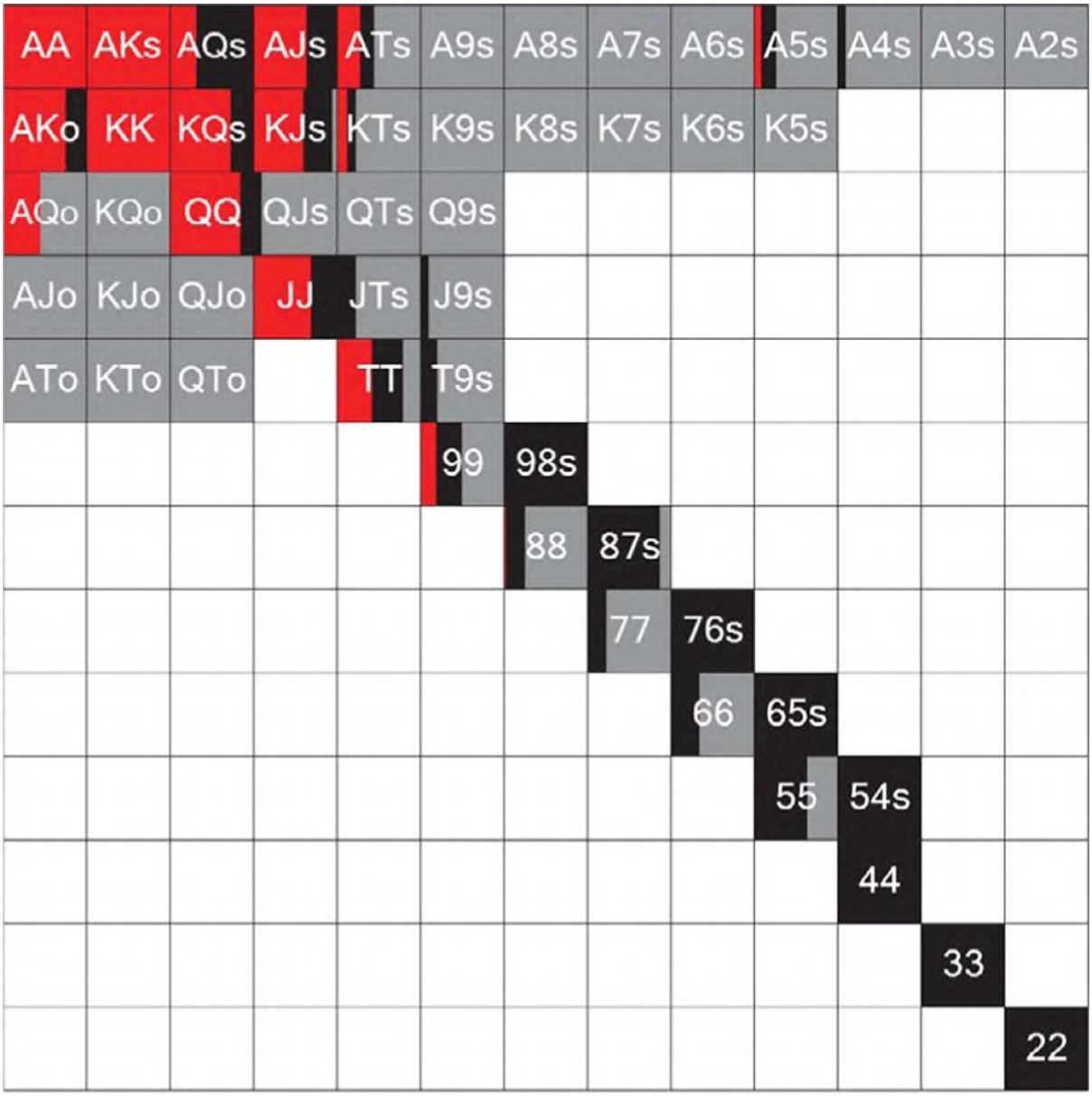


Diagram 10: LJ Response to 3-bets



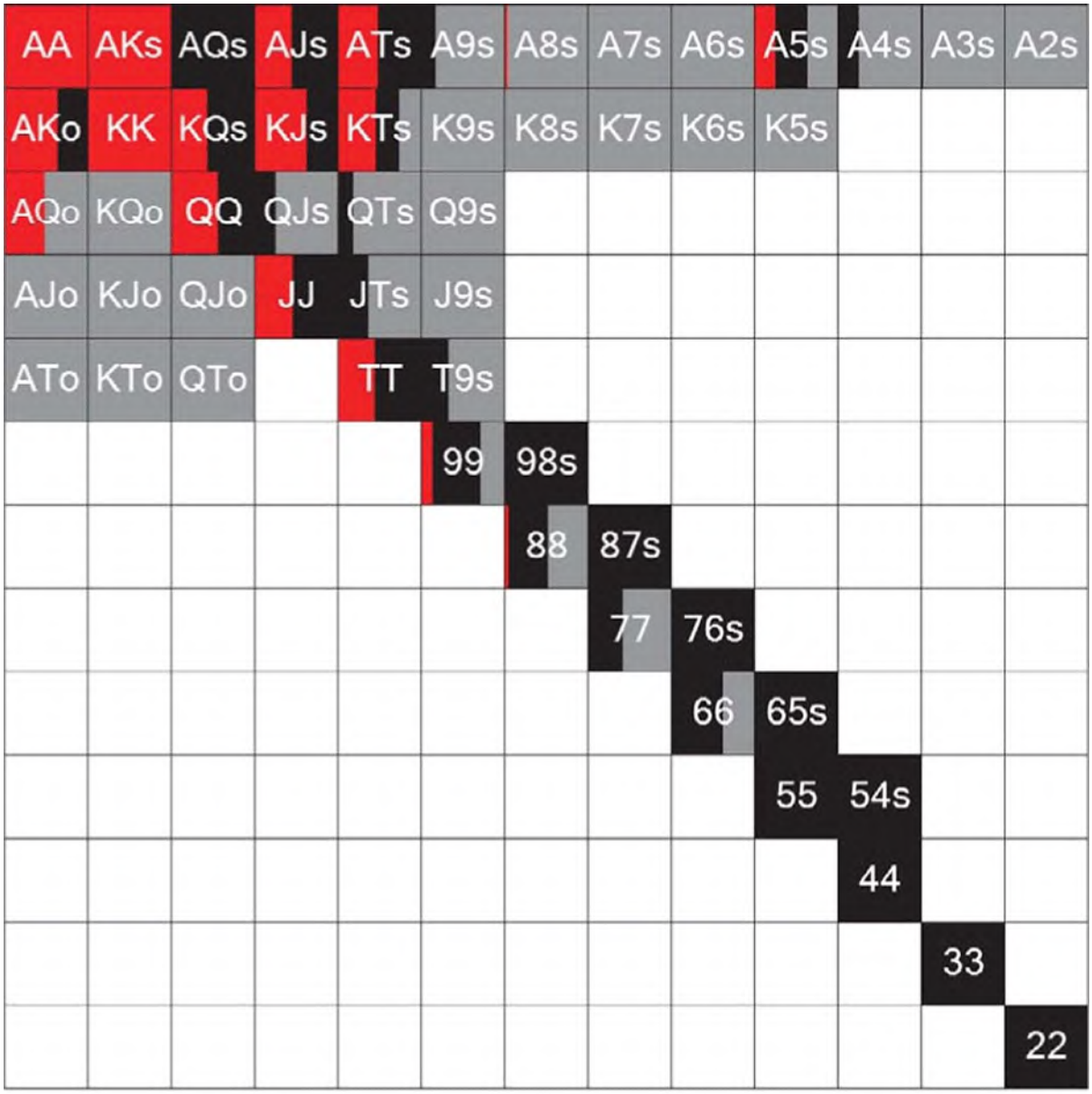
Hand Range 48: LJ vs HJ 3-bet

• 4-bet 21.8% / • Call 15.1% / • Fold 63.1%



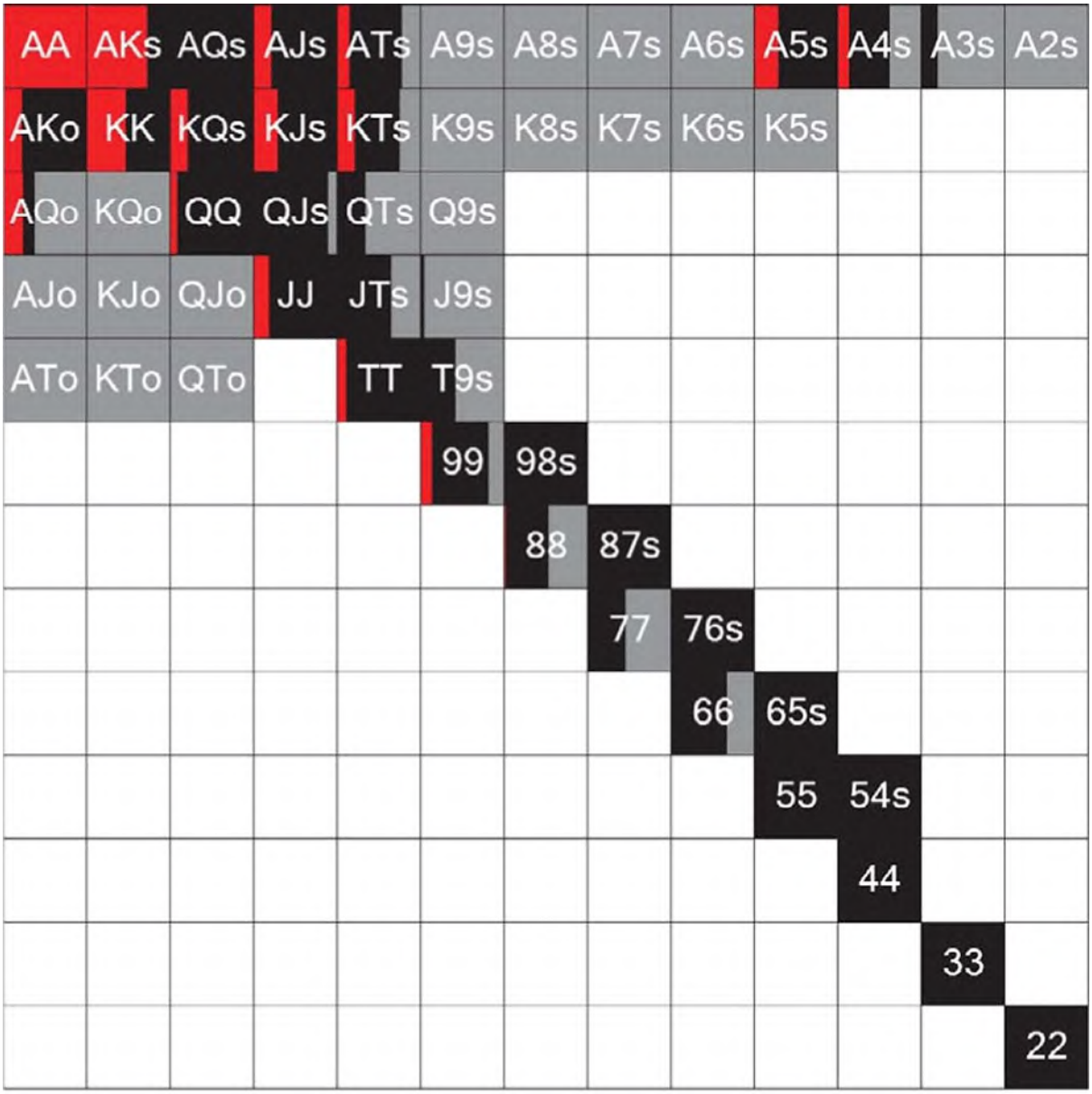
Hand Range 49: LJ vs CO 3-bet

• 4-bet 23.8% / • Call 13.8% / • Fold 62.4%



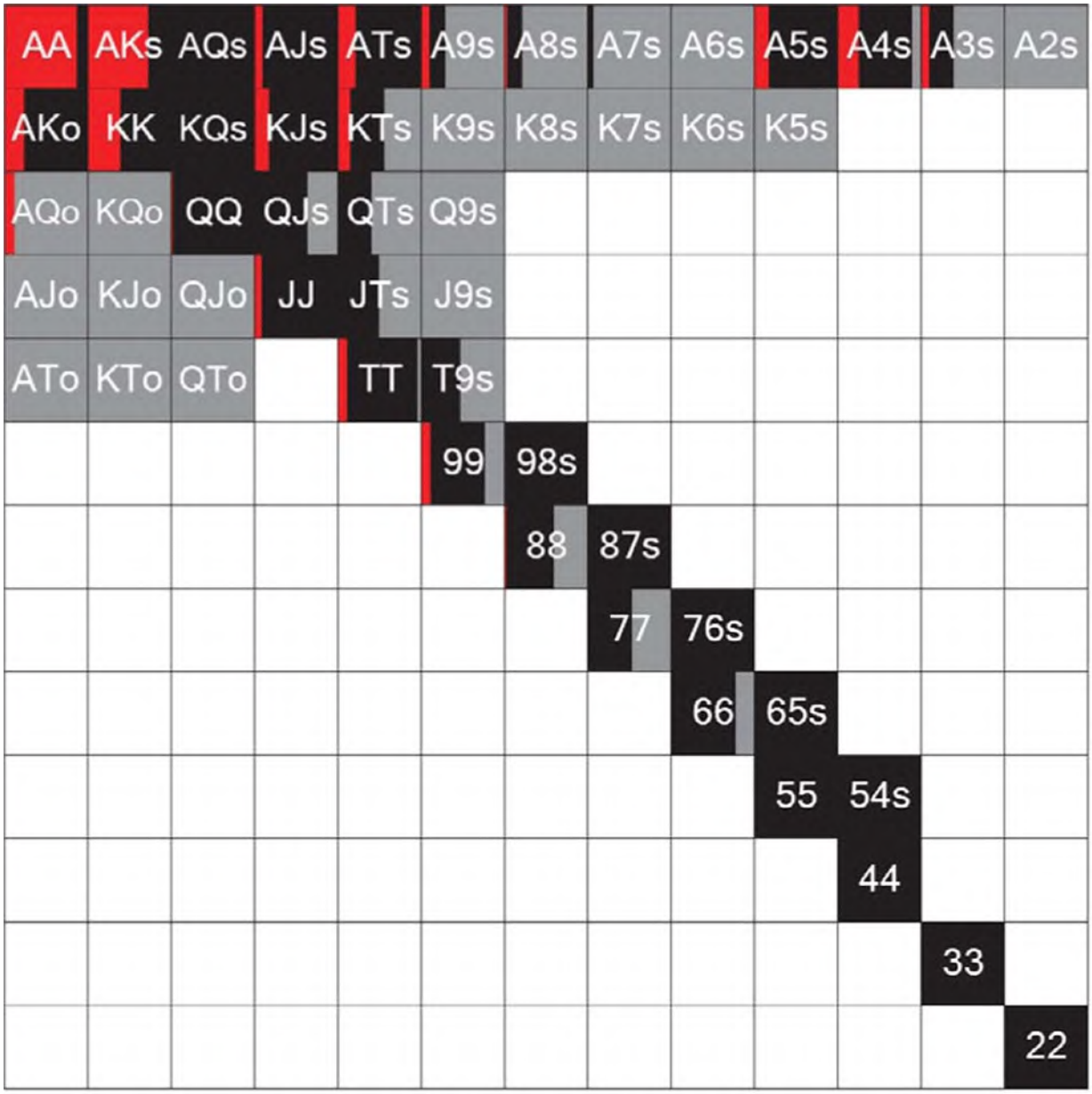
Hand Range 50: LJ vs BN 3-bet

• 4-bet 21.9% / • Call 23.3% / • Fold 54.9%



Hand Range 51: LJ vs SB 3-bet

• 4-bet 11.5% / • Call 36.6% / • Fold 51.9%



Hand Range 52: LJ vs BB 3-bet
• 4-bet 9.5% / • Call 38.8% / • Fold 51.7%

Playing vs 3-bets: General Heuristics

Well-constructed ranges are designed in such a way that they maximize the number of hands that can be played profitably while remaining unexploitable against the other players at the table. If a player attempts to play a BN range (~43% hands) from the LJ (~17% hands), they will get

destroyed because they will no longer be able to defend enough of this range (~48%) against the remaining players. They will have to fold way more than 52% of their range when facing 3-bets and will also have to call with many marginal hands that will give them a lot of trouble post-flop.

The only thing that stops players from 3-betting you relentlessly is your ability to 4-bet, as well as the likelihood of other players coming over the top. You must defend enough of your range against 3-bets so that Villains are indifferent to 3-betting you with the bottom of their range *(Diagrams 11 and 12)*.

You will get 3-bet a lot more often when opening UTG than when opening from the BN (despite your strong range) due to the number of players yet to act, and your opponents will have stronger ranges. Defending a wide range is a lot more difficult than defending a tight range, so you can't profitably open as many hands from UTG as you can from the BN. If your opponent's 3-betting range is polarized, more hands in your range will have the right equity to call due to being dominated less often, leading to better post-flop playability. So, you get to call more of your range against polarized ranges compared to linear ranges.

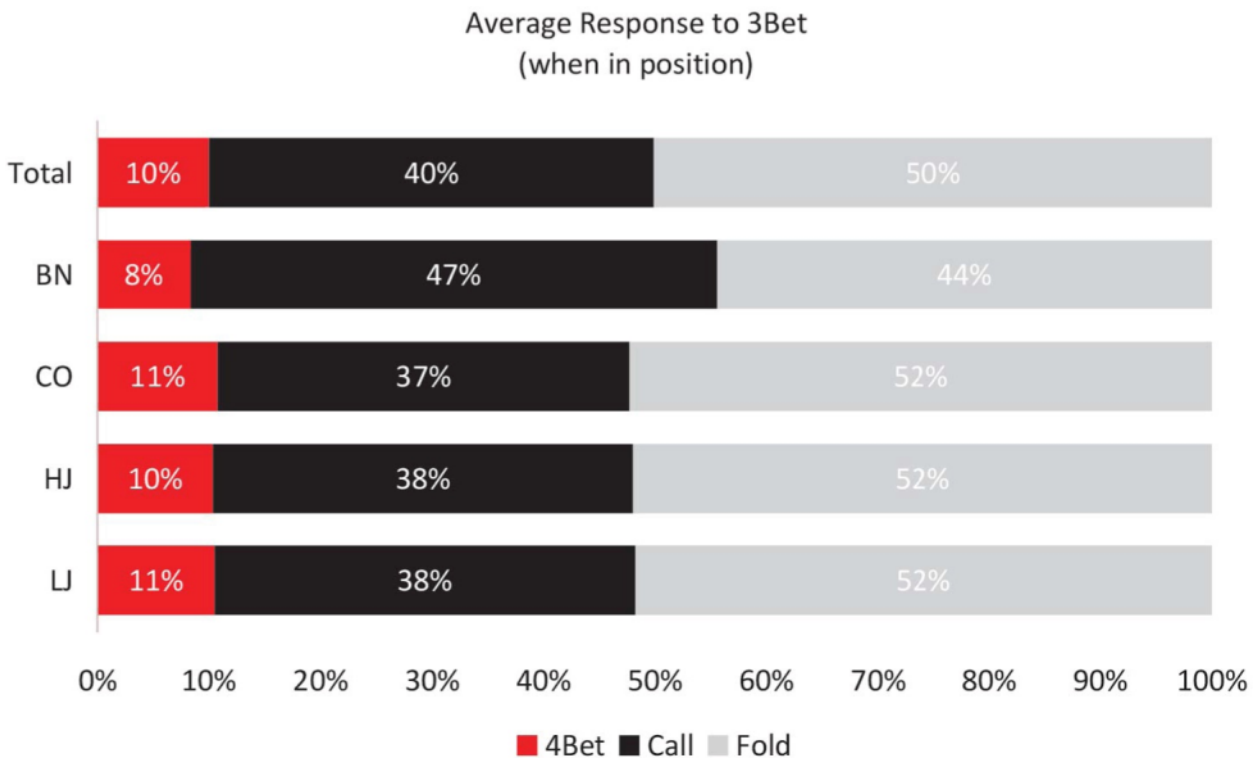


Diagram 11: Average Response to 3-bet (IP)

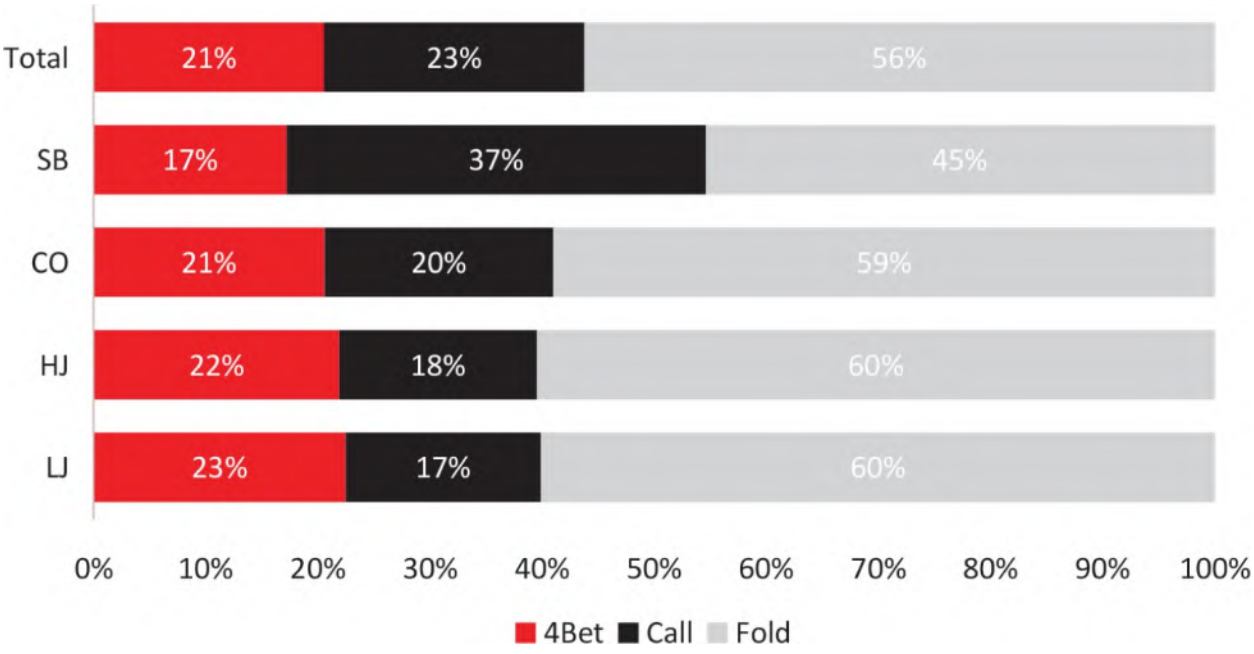


Diagram 12: Average Response to 3-bet (OOP)

Suited broadways, suited connectors and pocket pairs make good calling hands. Offsuit broadways and weak Ax don't play too well in 3-bet pots because they have very poor equity realization and bad reverse implied odds and so, in general, they get folded.

If you think someone is out of line with their 3-bet frequency then, to exploit them, you first need to assess how they will react to a 4-bet. If they will fold most of the time, you can 4-bet a polarized range, opting to bluff with hands that have good blockers, such A5s. If the Villain is likely to call your 4-bet with a wide range and only 5-bet premium hands, the best approach is to 4-bet a linear range so you extract immediate value and have a strong range post-flop. If the Villain is likely to 5-bet all-in wide, then don't be afraid to 4-bet/call off with hands such as AQ. Sometimes they will get your stack but, more often than not, you will get theirs.

The smaller your opponent's 3-bet size, the more hands in your range you need to defend in order to remain unexploitable. Against smaller sizes, you should call more hands and, conversely, the bigger the bet-size, the fewer hands you need to defend.

Rake effects are reduced in pots that are already inflated by pre-flop action. So when deciding to enter the pot by 3-betting or 4-betting, the main concern should be the ranges and equities in play.

When facing a 5-bet, your general getting in range should be TT+ and AK.

Once the action gets to you after an open raise and a 3-bet, in general you will 4-bet or fold. Splitting your range into cold calling and cold 4-betting presents problematic issues that give away information about your hand. Cold calling also allows active players to realize their equity

by calling many hands they would have folded vs a 4-bet, so the best approach is to simply cold 4-bet all of your continuing range or ~3% hands vs tight ranges and ~6% hands vs wide ranges *(Hand Range 53)*.

Hand Range 53: BB Cold 4-betting Versus: • LJ & HJ / • CO & BN / • BN & SB

General Strategy When Facing 3-bets vs Each Position

Your response to a 3-bet should vary depending upon which position the 3-bet comes from *(Diagram 13)*.

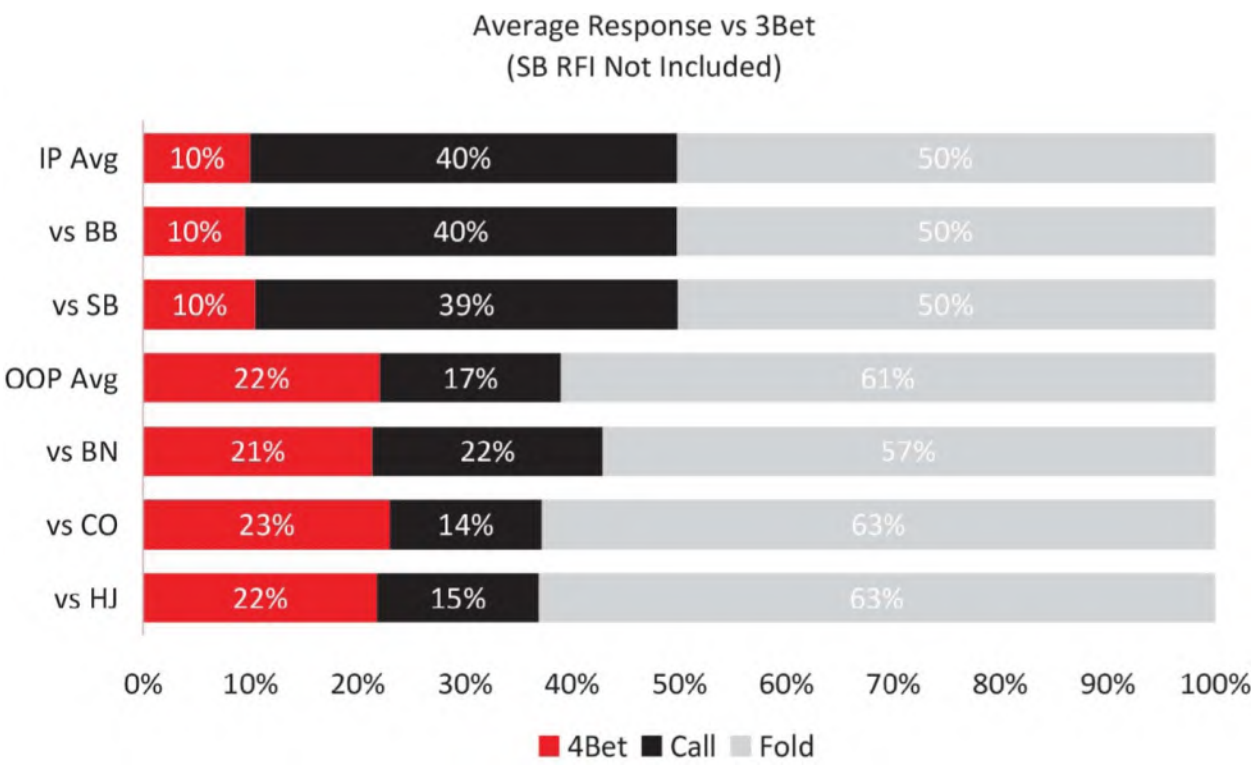


Diagram 13: Average Response vs 3-bet (SB RFI not Included)

Versus HJ 3-bet

Since the HJ is playing a 3-bet or fold strategy vs the LJ, their range will be very linear and overlap considerably with the the LJ range. The LJ's best response is to mostly defend by 4-betting to reduce their positional disadvantage by reducing the SPR and getting the HJ to fold some of their equity.

Versus CO 3-bet

Against the CO, you can 4-bet slightly wider than vs the HJ because the CO 3-bet range is slightly wider than the HJ 3-betting range. Also, you are happier getting all-in with JJ and TT pre-flop.

Versus BN 3-bet

The BN 3-bet range is more polarized than that of the HJ and CO because the BN has a small calling range, which means more hands in your range have the right equity to call the 3-bet. Your 4-betting range starts to get more polarized and middling hands like AQs, AJs and KQs get

called more often.

Versus SB 3-bet

You have position against the SB so you don't need to 4-bet as often as you do against the other positions. Now the only hands that really want to get all-in pre-flop are AA, KK and AKs. High equity hands such as suited broadways mostly want to call. So, pick the suited broadways and next-tier suited hands as your 4-bet bluffs. Premium pairs such as QQ and JJ like seeing flops, so they are 4-bet less often.

Versus BB 3-bet

The BB 3-betting range is polar and you have position, so your main defense will be to call and play post-flop in position with a solid range. You can start to slow play AA a small percentage of the time when you are in the HJ. Your 4-betting range against the BB is polarized and some of your frequent bluffs are A5s-A3s, AQo-ATo, some suited Kx. Suited broadways, suited connectors and big pairs make great calls because they play well in 3-bet pots and will realize a lot of their equity.

General Guidelines Playing Versus Open Raises

In this section we will discuss GTO 3-betting and exploitative 3-betting.

GTO 3-betting

When playing against tough players who you know have sound RFI strategies and will defend correctly against 3-bets, you should try to stick to equilibrium 3-betting strategies and, if possible, use some sort of randomization to help stay balanced. Furthermore, you must be careful not to get exploited, meaning you must defend your 3-bets correctly against 4-bets.

When considering 3-betting, you need to assess the strength of Villain's range. The stronger their range, the stronger hands you should pick as bluffs (you must pick stronger hands to use as a bluff vs the LJ than vs the BN).

If you have a flat calling range (mostly from BN or when IP), then your 3-bet range has to be polarized because you are flatting high equity hands that don't want to get 4-bet. Therefore, your

3-betting range will consist of your best hands plus the next tier of hands that are not great calls, have equity or good blockers and can offer good board coverage.

If you don't have a flat calling range (mostly in the HJ, CO and SB), then your 3-betting range must be linear. If you are playing a 3-bet or fold only strategy, you want to put only your best hands in the 3-betting range and fold everything else.

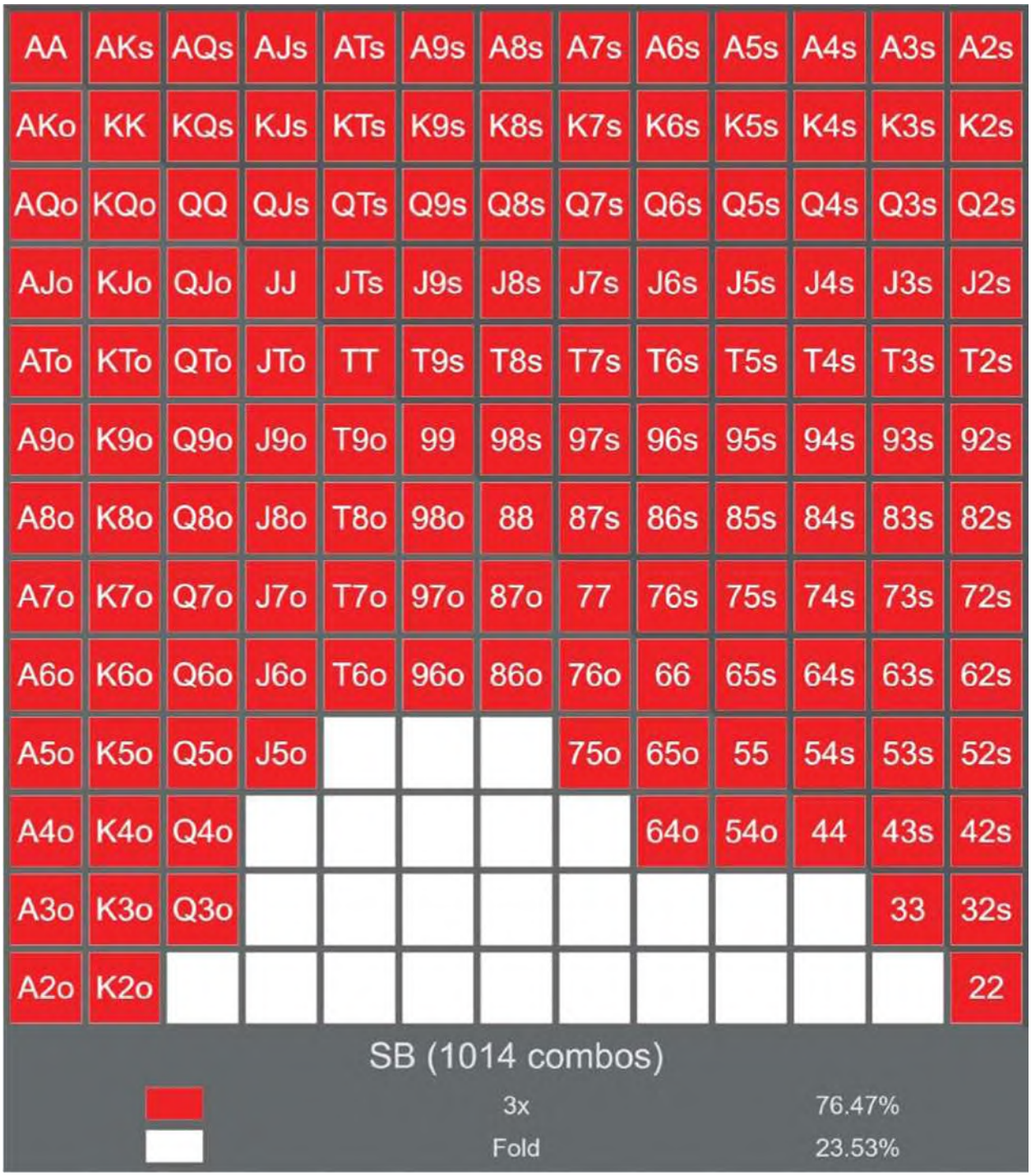
When you want to split your range into a calling range and a re-raising range, if stack depths are such that the Villain can re-raise all-in, you want your re-raising range to be polarized. This is because you want to put all high equity hands that you don't want to re-raise/fold in your flatting range.

Exploitative 3-betting

When you suspect Villain is a weak player and or is opening more hands than they should, you should try to exploit them by increasing your 3-betting frequencies. However, you must be careful if there are other active players in the hand because if they pick up on what you are doing, they can start cold 4-betting wider and exploit you, even if the weak player never realizes you are exploiting them.

The best way to assess quickly if a Villain might be over-folding to 3-bets is to use MDF and the Alpha number.

Example
Game: Live Cash Game
Effective Stack: $500
Players: 8
Blinds: $2/$5 (no ante)
Pre-flop: The action folds to the SB who raises to $15. You have seen him make some questionable opens with Q3o and 64o from SB before, so you estimate they may be opening approximately 76% hands *(Hand Range 54)*.



Hand Range 54: Villain's SB Range

Hero is in the BB with K♦2♠.

Can Hero profitably exploit this Villain by 3-bet bluffing with K♦2♠?

Using the Alpha number equation, if you 3-bet Villain to $45, you risk $40 to win $20:

$$Alpha = \frac{b}{b + p}$$

$$Alpha = \frac{40}{40 + 20}$$

$$Alpha = \frac{2}{3} = 0.67$$

$$MDF = 1 - Alpha$$

$$MDF = 1 - 0.67 = 0.33$$

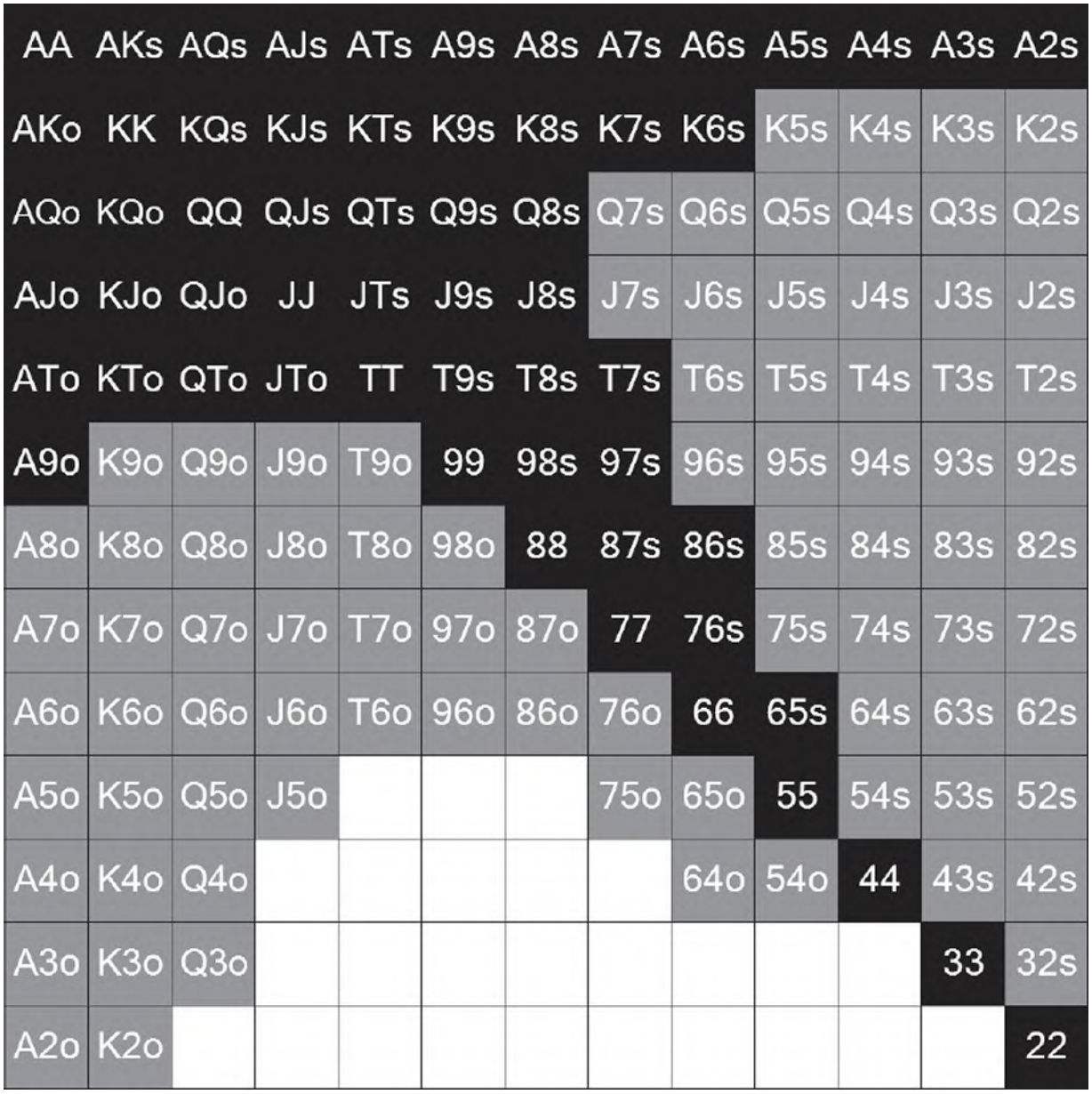
Villain's full range (76.47% hands) contains 1,014 combos.

$$Defending\ Range = MDF * 1014$$

$$Defending\ Range = 33\% * 1014$$

$$Defending\ Range = 334.62$$

So, if Villain is defending with fewer than 334.62 combos, you have an immediately profitable bluff.



Hand Range 55: SB Defense vs BB (350 combos) [Fishy Player] • Defended 34.5% / • Folded 65.5%

You can see in *Hand Range 55* that the SB defending range contains 350 combos, so you don't have an immediately profitable bluff with ATC, but your hand, K♦2♠, has a valuable blocker to Villain's continuing range. The K♦ blocks continuing hands such as AK, KK, K6s+, and KTo+. By having the K♦ blocker in your hand, Villain's defending range decreases from 350 to 324 combos, making your 3-bet bluff now show an immediate profit.

There are two main types of exploitative 3-betting.

- **Polarized 3-betting:** If Villain is more likely to 4-bet or fold than to call, you can increase your 3-bet range to include more hands that have good blockers to their continuing range. For example, AJo, A5s, and KJs can flat call because they are high equity hands that you don't want to 3-bet/fold.

- **Linear 3-betting:** If Villain is more likely to call your 3-bets than 4-bet, then you want to 3-bet a linear range made of high equity hands that also have great post-flop playability and will dominate Villain's flatting range.

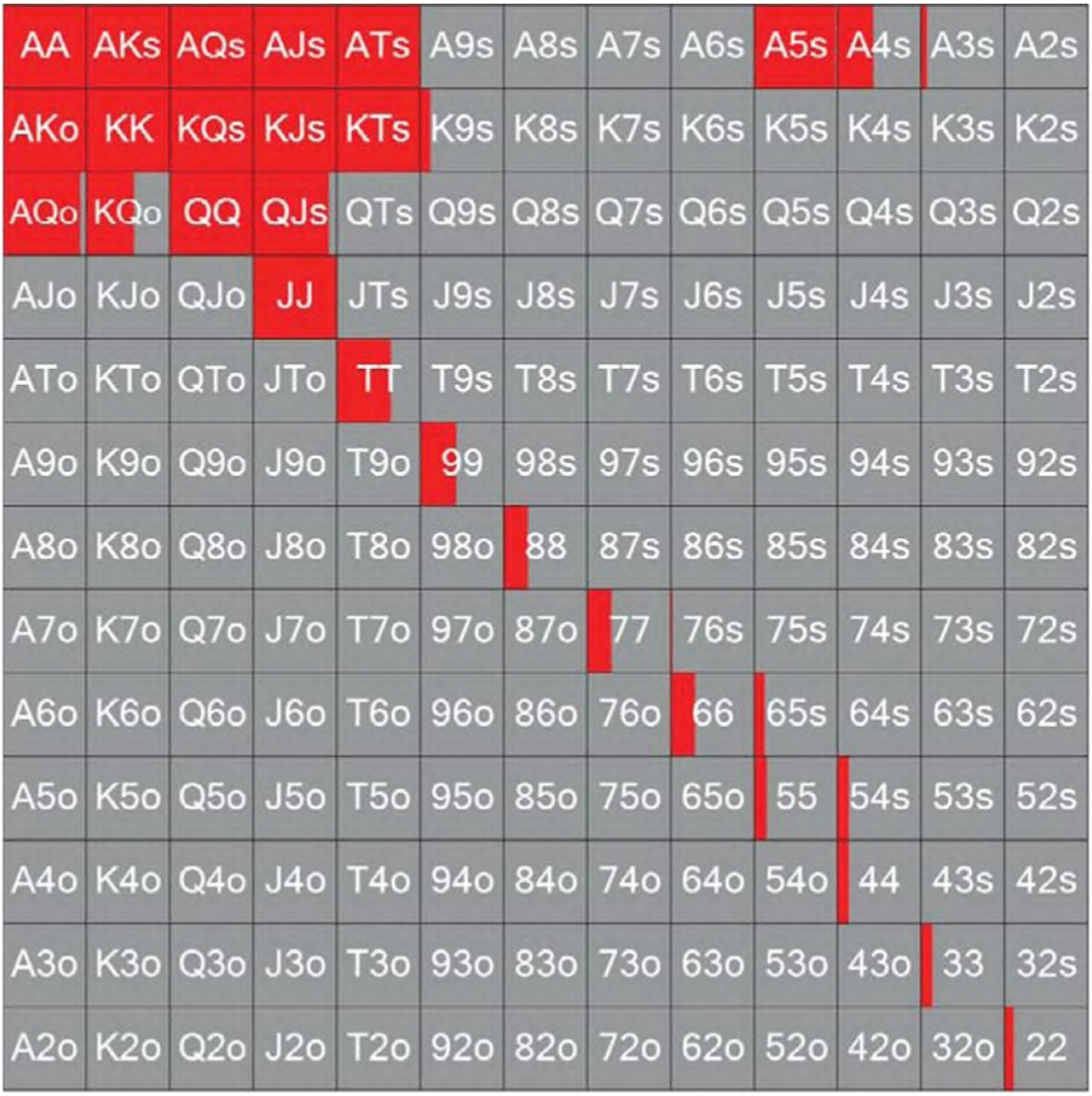
Specific Ranges Playing Versus Open Raises

Here we analyse the GTO solutions to playing vs open raises from each position and discuss the key factors that are implied by the construction of the ranges.

Hijack

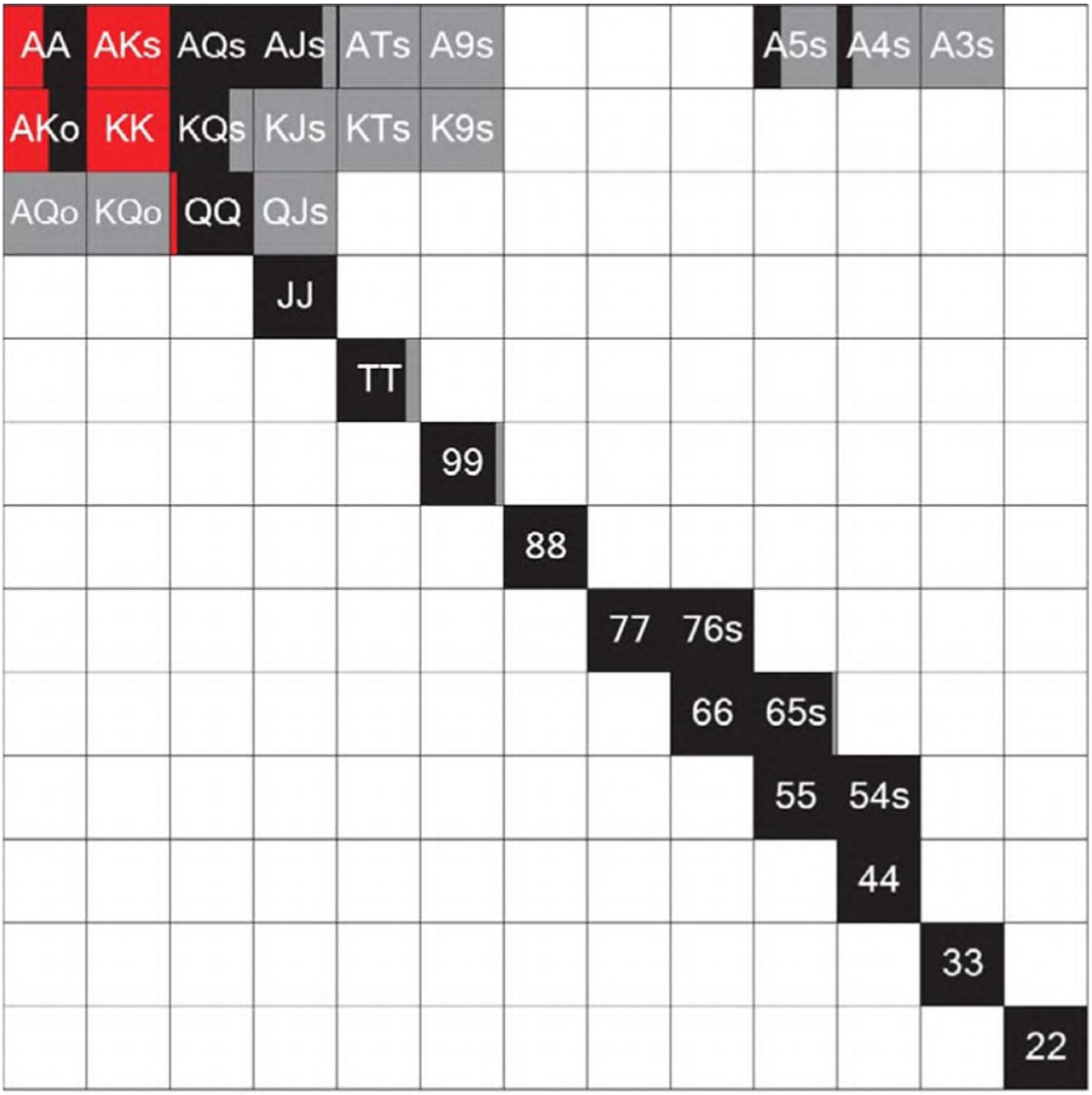
The HJ plays a 3-bet/fold strategy with no calling range when facing the LJ's raise *(Hand Range 56)*. From this position the maximum number of hands you can 3-bet and remain unexploitable is ~8% hands. It might be surprising to the reader that this strategy has a small weight in pocket pairs such as 88 to 22, because if 88 is clearly better than 22 then why not only 3-bet 88 more frequently instead of 22? The main reason is that you want to have good post-flop board coverage and be able to hit sets and other strong hands on many different types of flop texture. Another reason is that if you only 3-bet specific hands, your opponents will be able to use their blockers more effectively against you.

Against a LJ 4-bet, you want to 5-bet ~18.4% of the time, but since you have position, your main response is still going to be to call with most of your continuing range, slowplaying AA 52% of the time and just calling pairs that are weaker than KK. Other hands that like taking flops are the small suited connectors, AKo (46%), AQs, AJs, KQs and a small fraction of A5s-A4s *(Hand Range 57)*.



Hand Range 56: HJ vs LJ Open

• 3-bet 8.1% / • Fold 91.8%



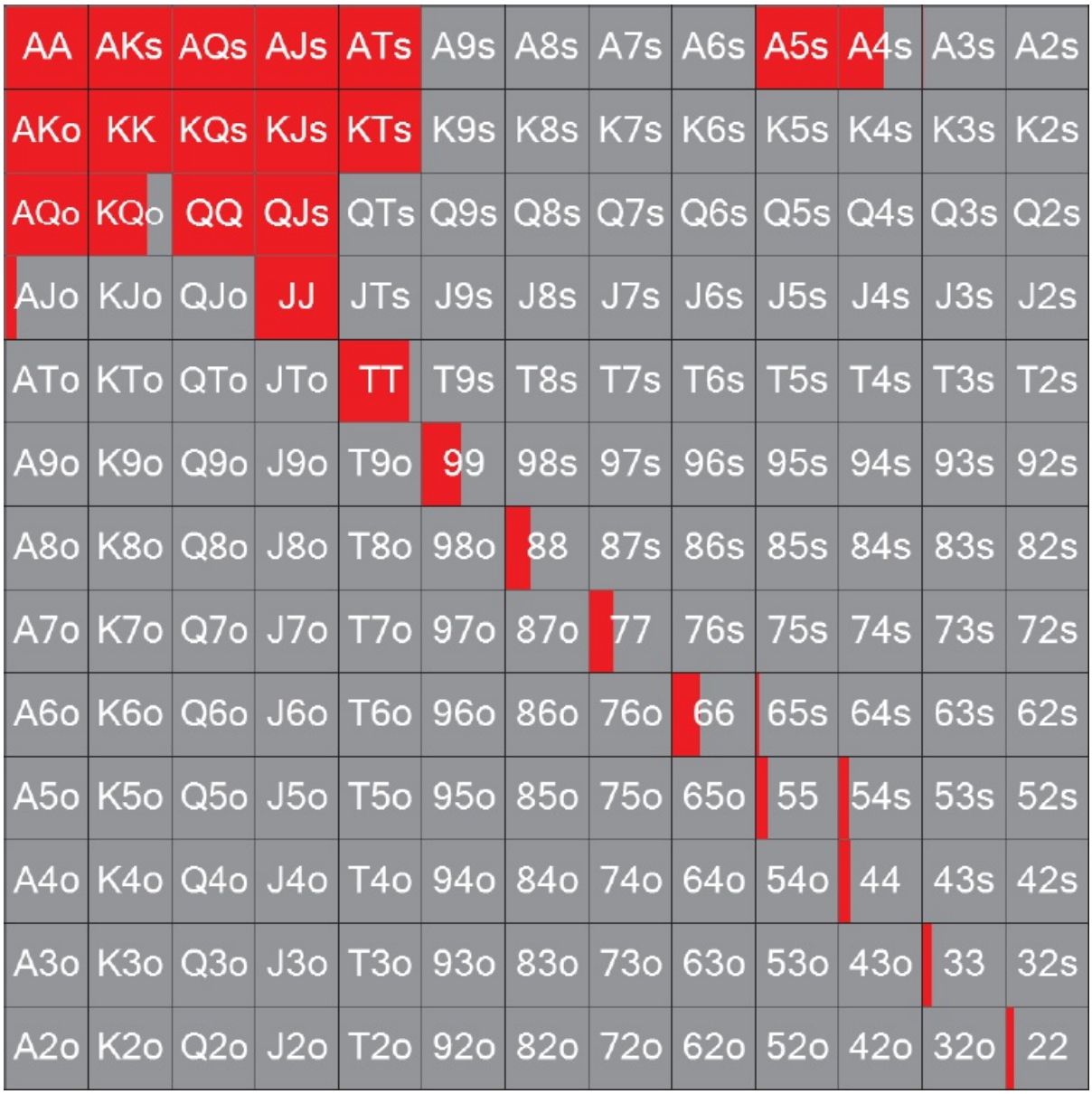
Hand Range 57: HJ vs LJ 4-bet
• 5-bet All-in 18.4% / • Call 43.3% / • Fold 38.3%

Cutoff

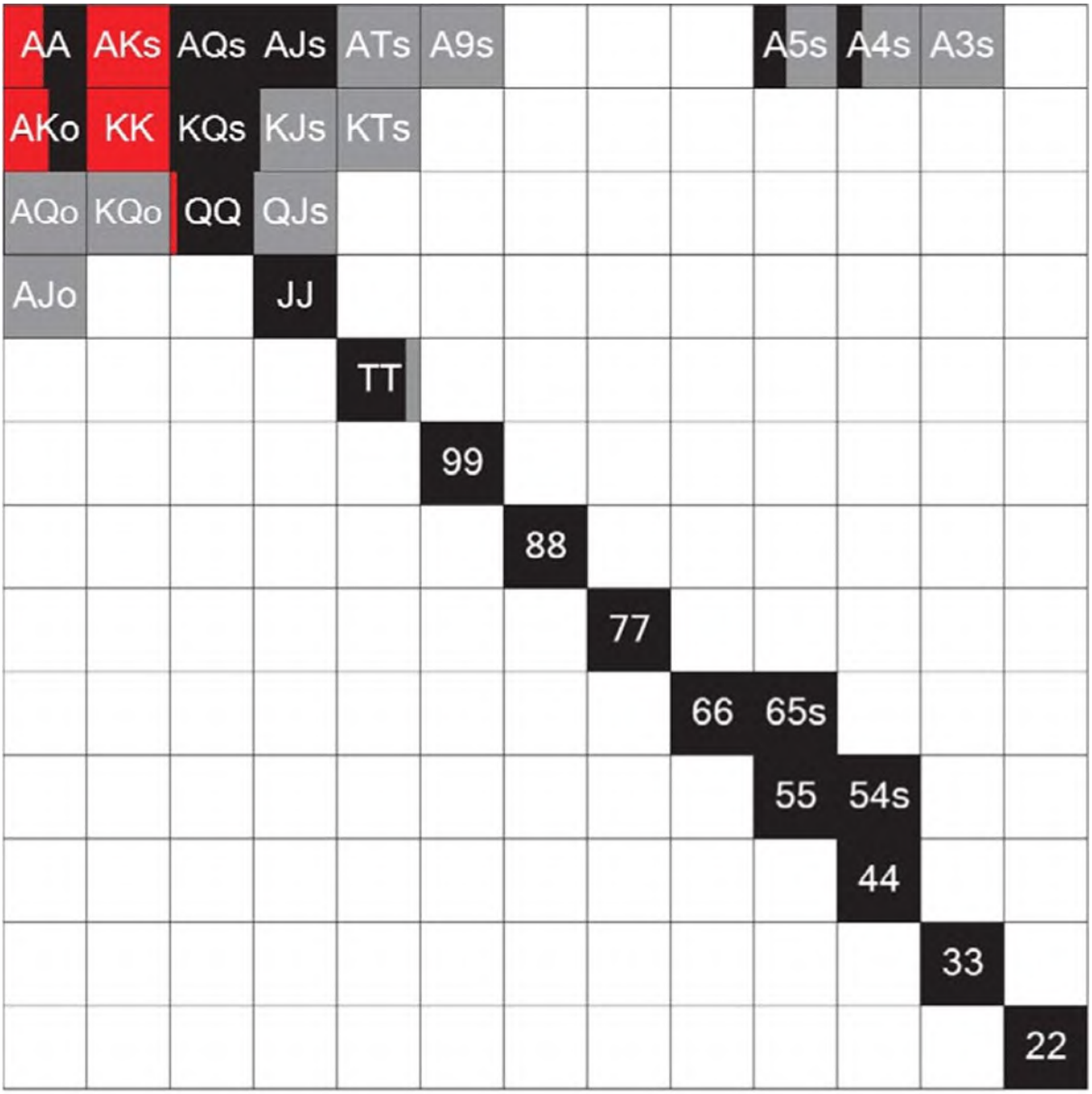
The CO 3-betting range vs LJ open is slightly wider than the HJ vs LJ one because now there is one fewer Villain to worry about *(Hand Range 58)*. Still, the LJ range is strong enough by itself, so you only get to 3-bet 0.5% more often.

The hands that really want to get all-in pre-flop are KK and AKs (100%). QQ only wants to get all-in ~7% of the time. AA is slowplayed 48% of the time, and AKo gets called 46% of the

time. A5s calls 39% and A4s calls 30% *(Hand Range 59)*.



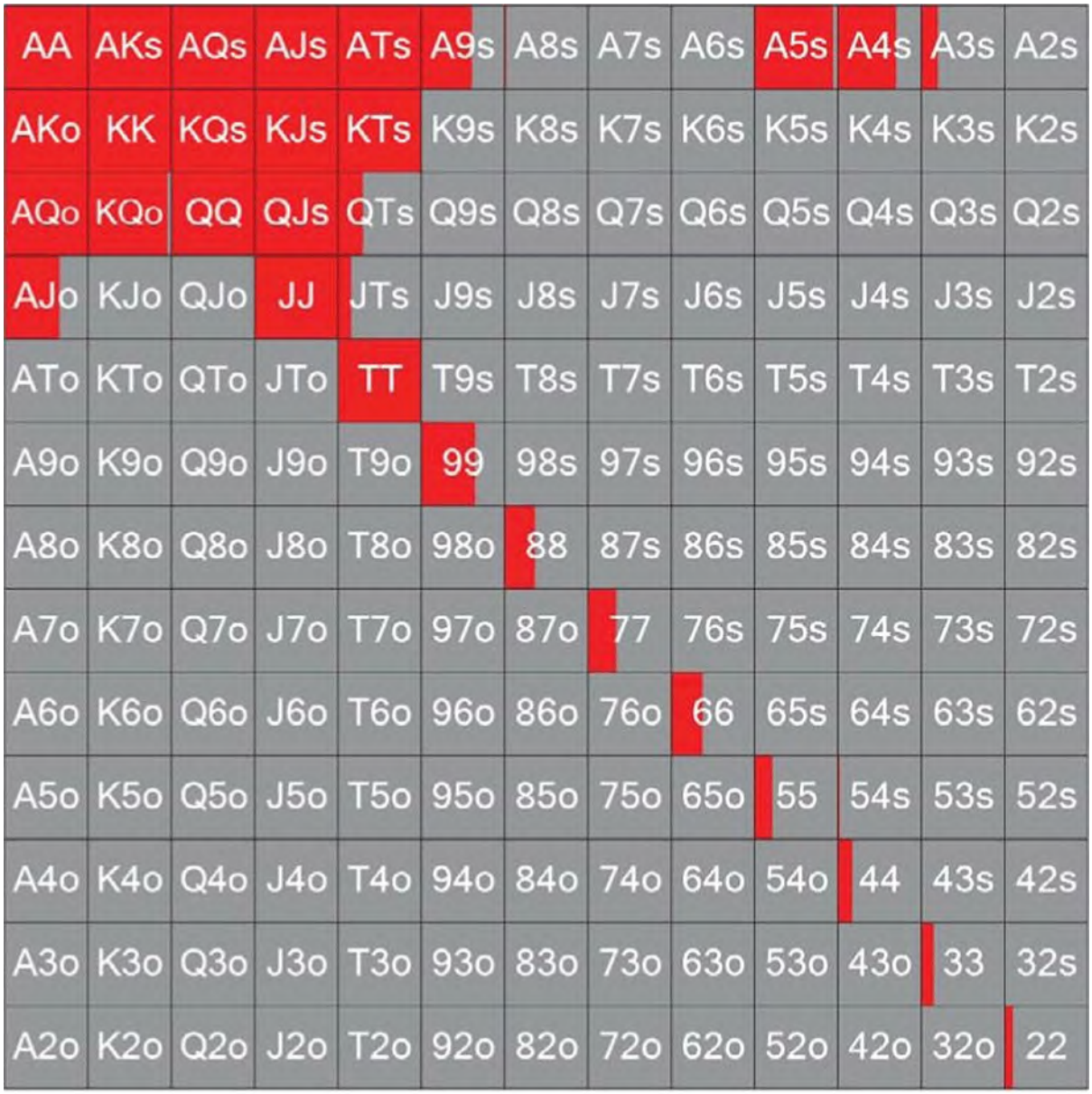
Hand Range 58: CO vs LJ Open • 3-bet 8.6% / • Fold 91.4%



Hand Range 59: CO vs LJ 4-bet
• 5-bet All-in 17.5% / • Call 45.1% / • Fold 37.4%

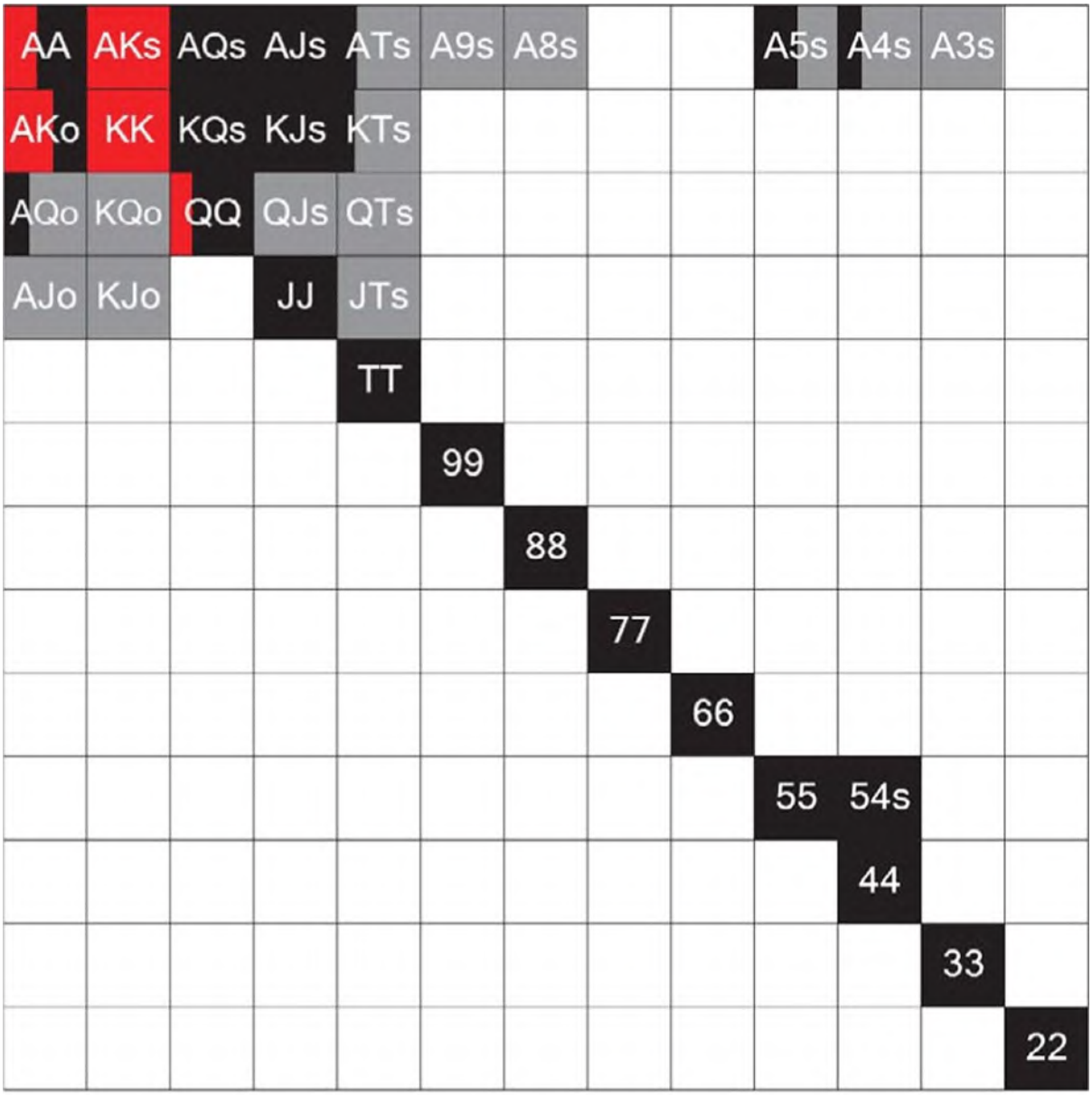
Against the HJ, the CO can 3-bet a wider range than vs the LJ because the HJ is opening ~21% hands, while LJ is opening only ~17% hands. You widen your 3-betting range to include hands such as A9s (61%), QTs (30%), and JTs (16%) and by increasing weights in the other threshold hands *(Hand Range 60)*.

Since your 3-betting range vs the HJ is wider, you need to defend a few extra hands against the 4-bet to remain unexploitable, so now you also call KJs (100%), ATs (24%), and KTs (21%) *(Hand Range 61)*.



Hand Range 60: CO vs HJ Open

• 3-bet 9.9% / • Fold 90.1%



Hand Range 61: CO vs HJ 4-bet
• 5-bet All-in 16.1% / • Call 48.2% / • Fold 35.8%

Button

The BN is the only position that doesn't have to worry about being out of position post-flop if someone else decides to enter the pot. Unlike the LJ, HJ, and CO, the BN has a calling range vs opens, so the BN 3-betting range is more polarized *(Diagram 14)*.

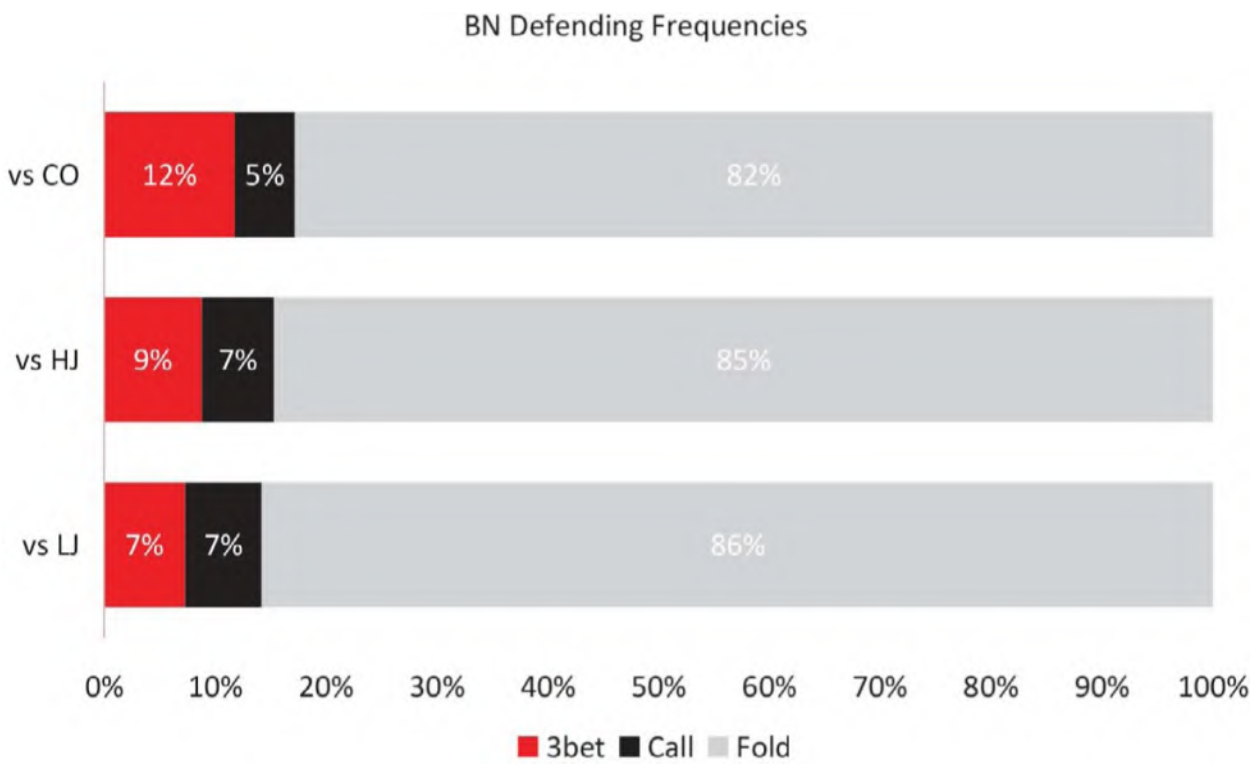
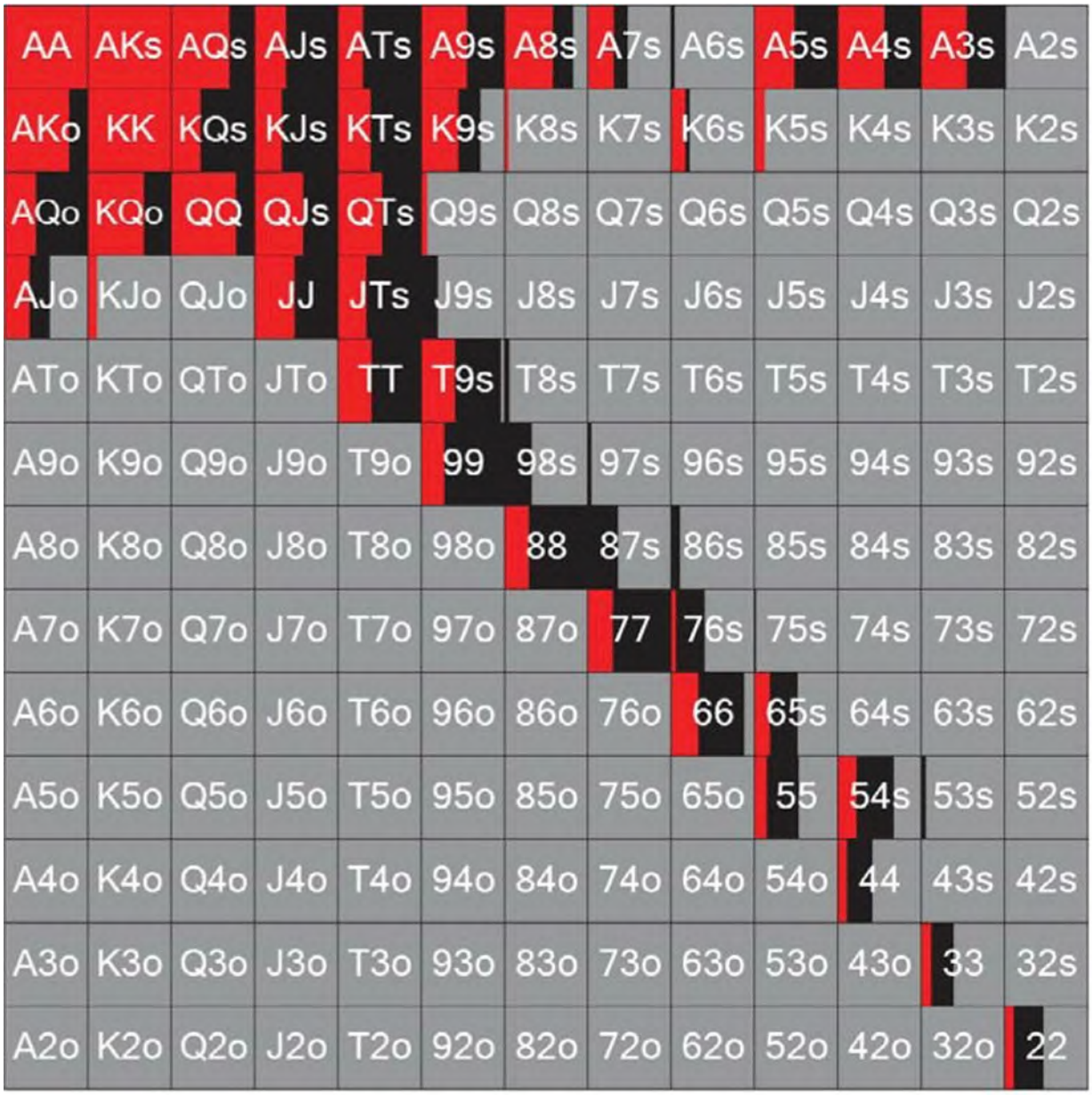


Diagram 14: BN Defending Frequencies

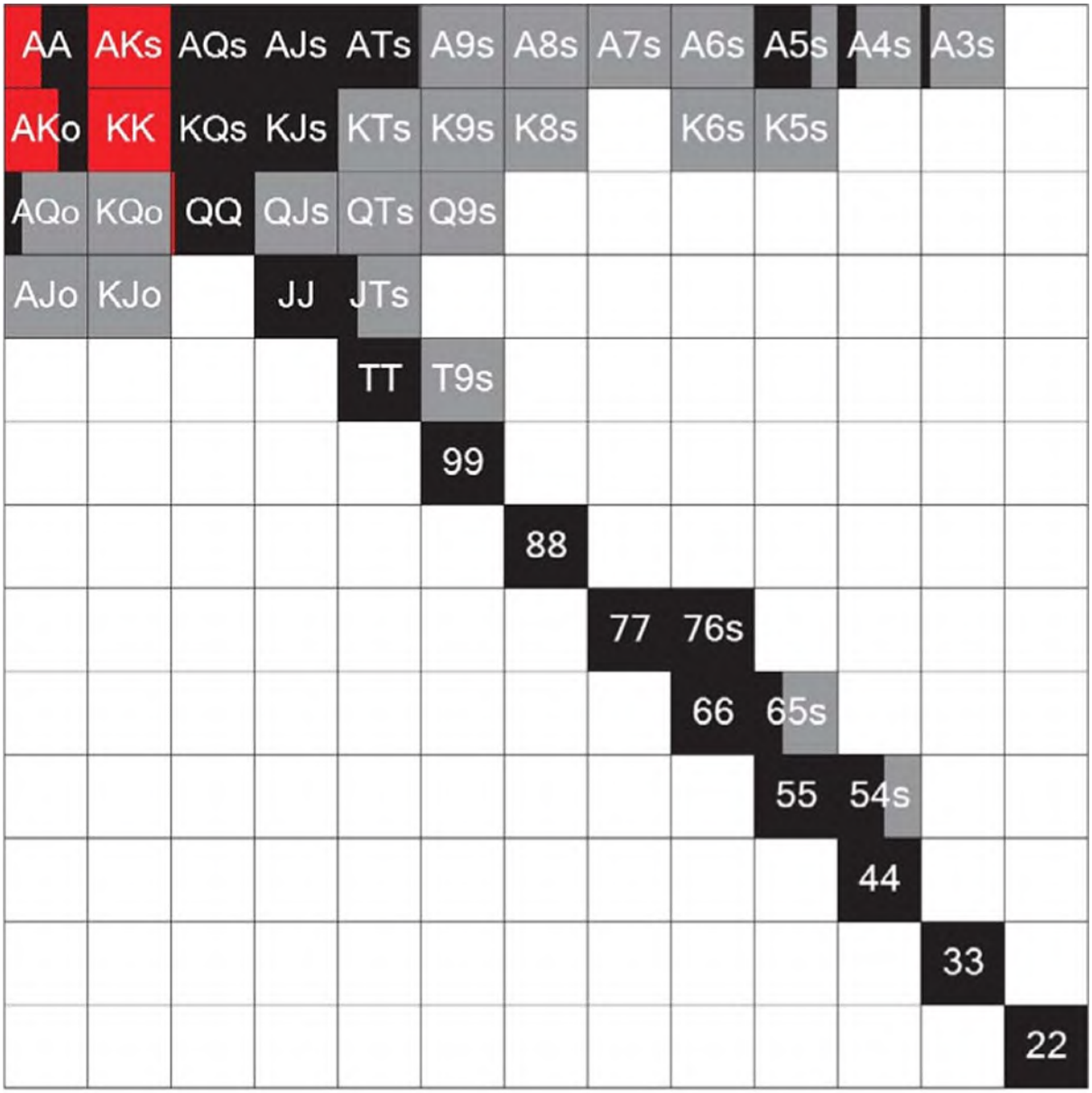
Your flatting range is made of hands that have good post-flop playability and offer good board coverage. You protect your calling range by slowplaying hands such as QQ (22%), JJ (52%), TT (59%), 99 (72%), and AKo (23%), as well as hands that can call against squeezes and play post-flop such as AQs (30%), AJs (37%), ATs (71%), KQs (65%), KJs (67%), KTs (30%) and QJs (41%) *(Hand Range 62)*.



Hand Range 62: BN vs LJ Open
• 3-bet 7.3% / • Call 6.9% / • Fold 85.8%

When you see some singularities such as K6s-K5s and 53s in *Hand Range 62* it's important to notice that these outliers are more likely to be due to convergence in the GTO solution than some "groundbreaking" discovery, so in practice you should be fine simply ignoring them.

At this point, the LJ 4-betting range is strong enough that you are fine 5-betting a range of KK, AKs, AKo (64%), AA (44%), and QQ (5%) from the BN as LJ should still continue ~58% of the time vs the shove. Again, since you have position, the bulk of your range is defended by calling a lot of hands that have good equity vs LJ 4-betting range *(Hand Range 63)*.

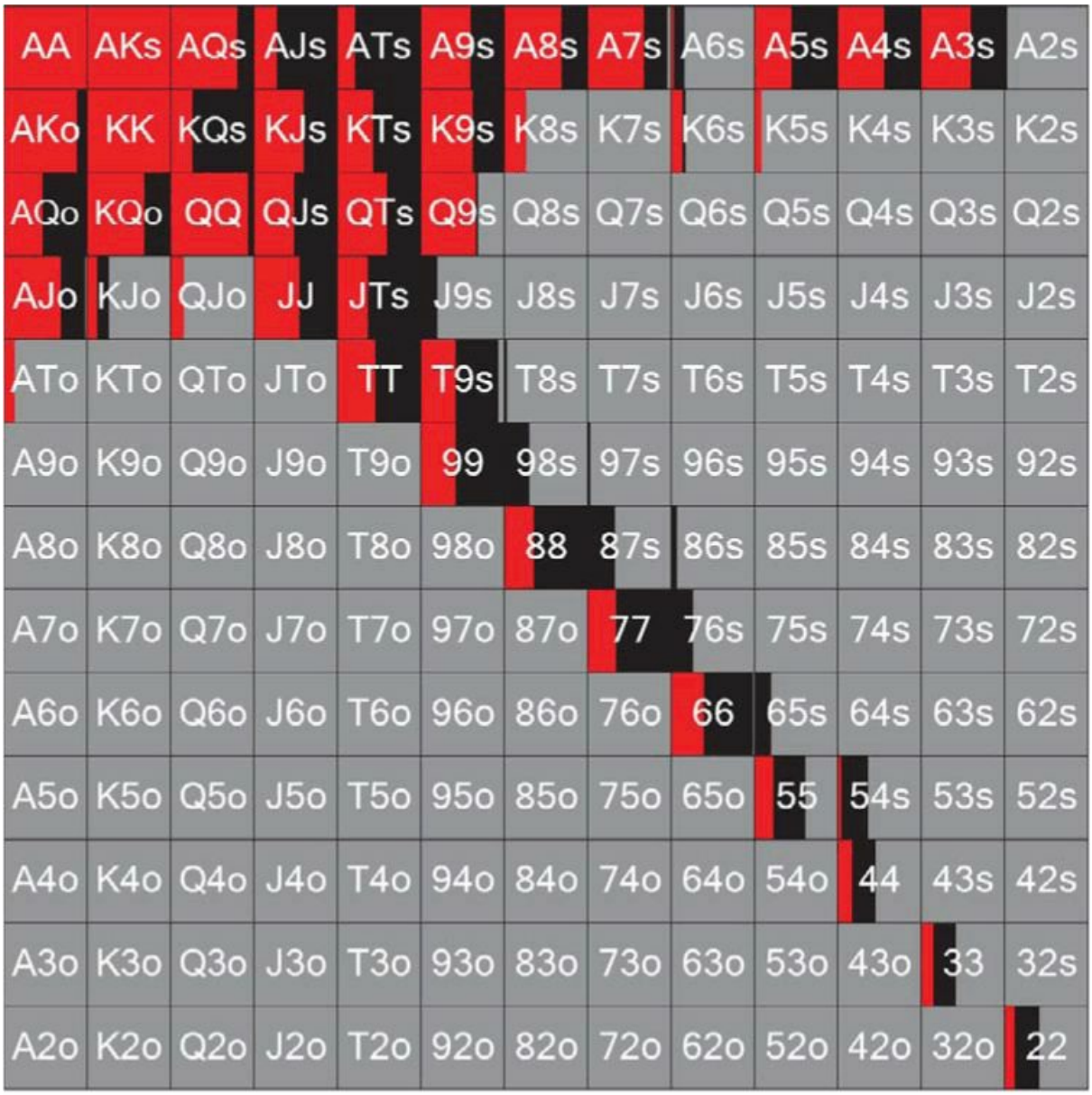


Hand Range 63: BN vs LJ 4-bet
• 5-bet All-in 19.4% / • Call 40% / • Fold 40.6%

Against HJ raises, the BN flatting frequency goes down a little bit because you now have a little less protection against squeezes, given the blinds can 3-bet more vs the HJ than vs the LJ. At the same time, the BN can 3-bet more vs the HJ, so your 3-betting frequency increases 1.5% and your overall folding frequency decreases 1.2%. A few hands that get added to your 3-betting range are strong blocker hands such as QJo (16%), and ATo (13%) *(Hand Range 64)*.

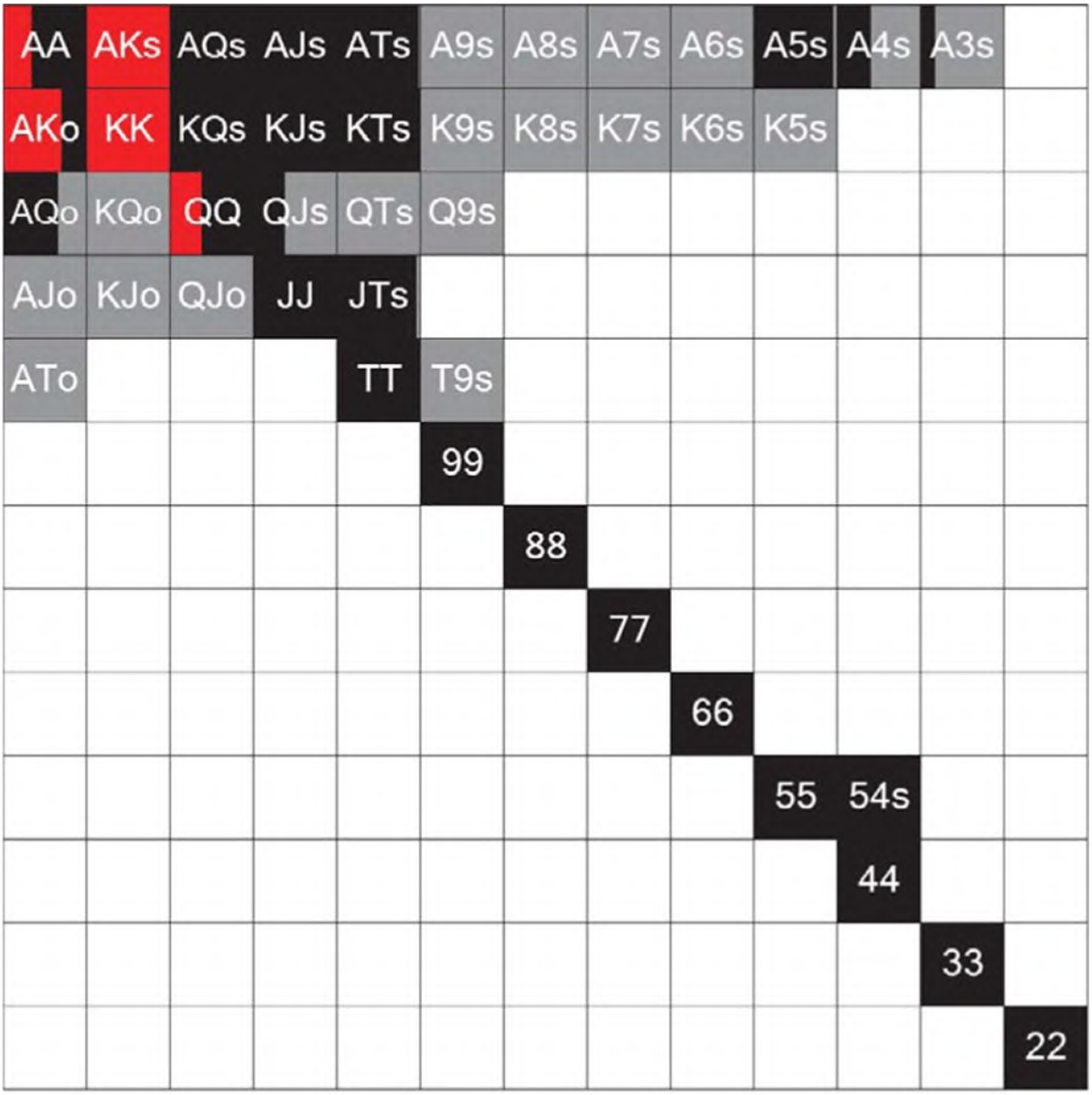
Against HJ 4-bets, the BN starts 5-betting QQ (38%) and incorporates more calling, using hands such as AQo (66%), KTs, QJs (38%), JTs (96%), A5s (96%), A4s (40%), A3s (17%), and

54s *(Hand Range 65)*.



Hand Range 64: BN vs HJ Open

• 3-bet 8.8% / • Call 6.5% / • Fold 84.6%



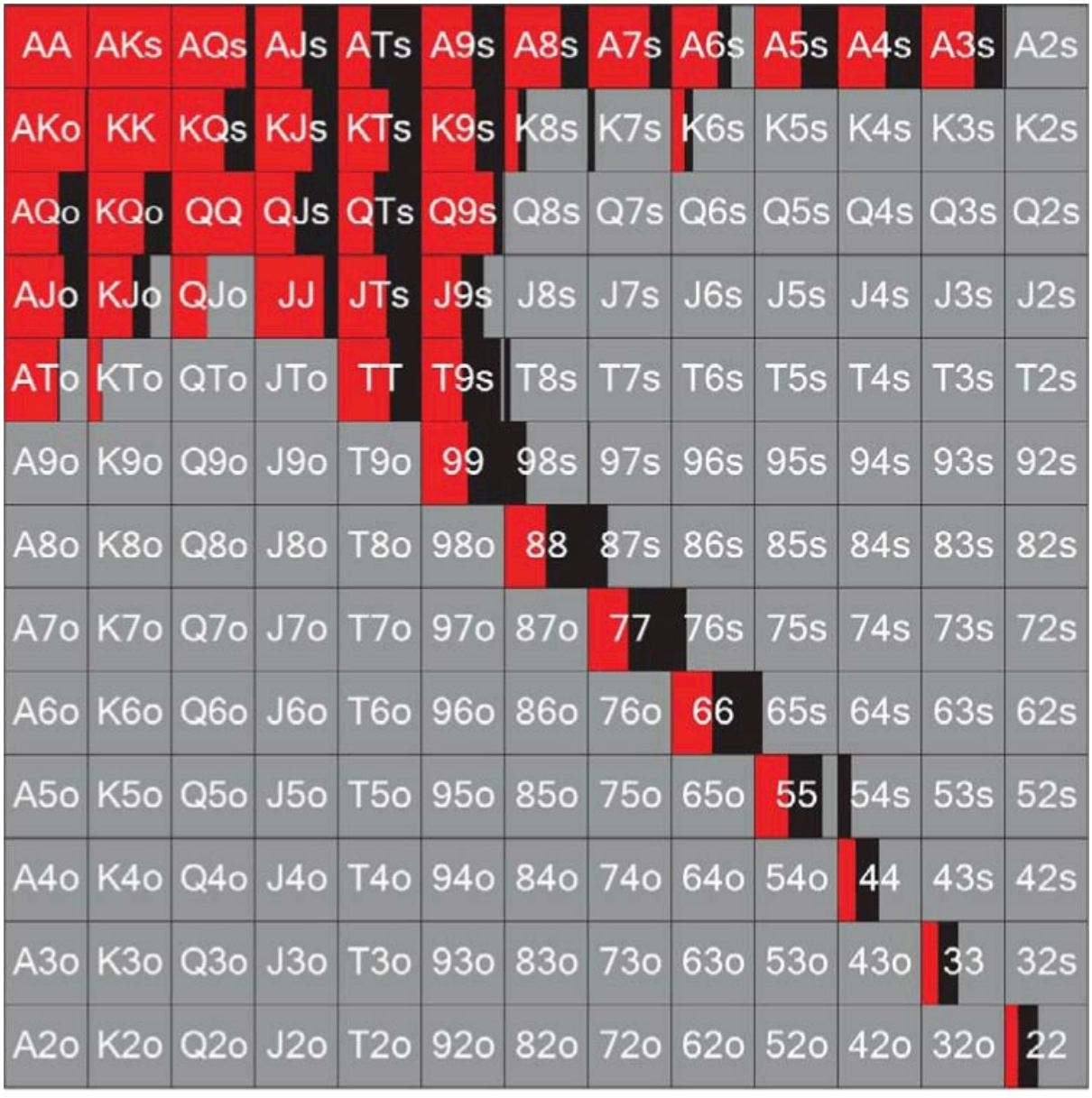
Hand Range 65: BN vs HJ 4-bet
• 5-bet All-in 18.4% / • Call 41.6% / • Fold 40%

Notice that this chart only represents hand frequencies and not exactly how often the hand is in the range. So, for example, 54s should be read as a call 100% of the time when you have it, but if you look back at the BN vs the HJ 3-betting chart, 54s is only being 3-bet 4% of the time, so you barely have it in your range when you face the 4-bet.

Against a CO open, the BN calling range continues to shrink because the blinds will squeeze more often vs the CO than vs the HJ and LJ. The BN 3-betting range vs the CO increases to

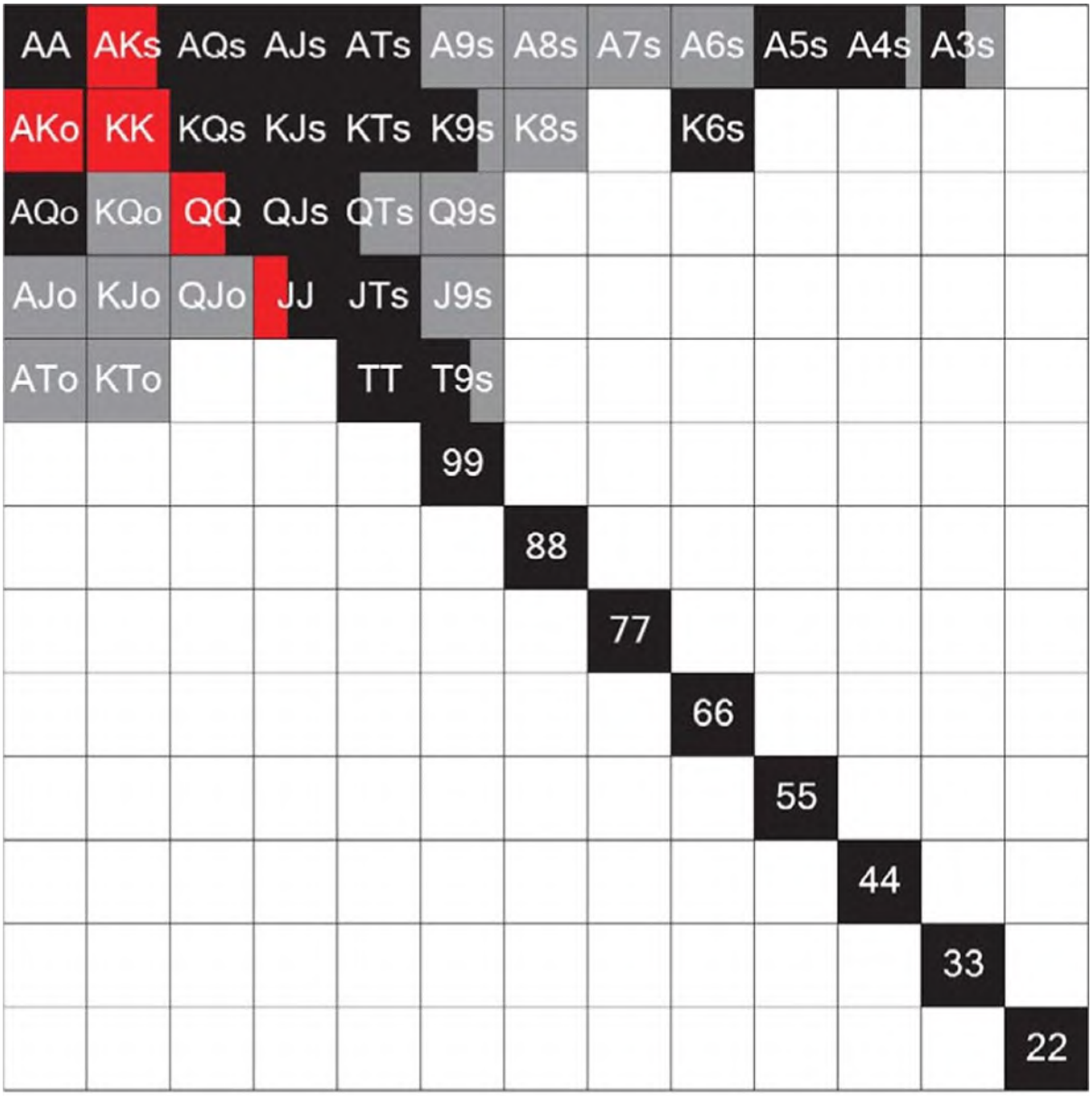
11.7% and the folding frequency decreases to 82.3%. The BN 3-betting range now incorporates more suited Ax and offsuit broadways, focusing more on high card value *(Hand Range 66)*.

The CO 4-betting range is wider and a little more polarized than that of the HJ, so you can defend more of your range by calling. At this point, AA slowplays 100% of the time. You also increase the calling frequency of hands such as AQo, QJs, JTs, and K9s (68%). You begin to incorporate 4-bets with JJ (40%) and increase the 4-betting frequency of hands such as AKo (96%), and QQ (66%) *(Hand Range 67)*.



Hand Range 66: BN vs CO Open

• 3-bet 11.7% / • Call 5.4% / • Fold 82.3%



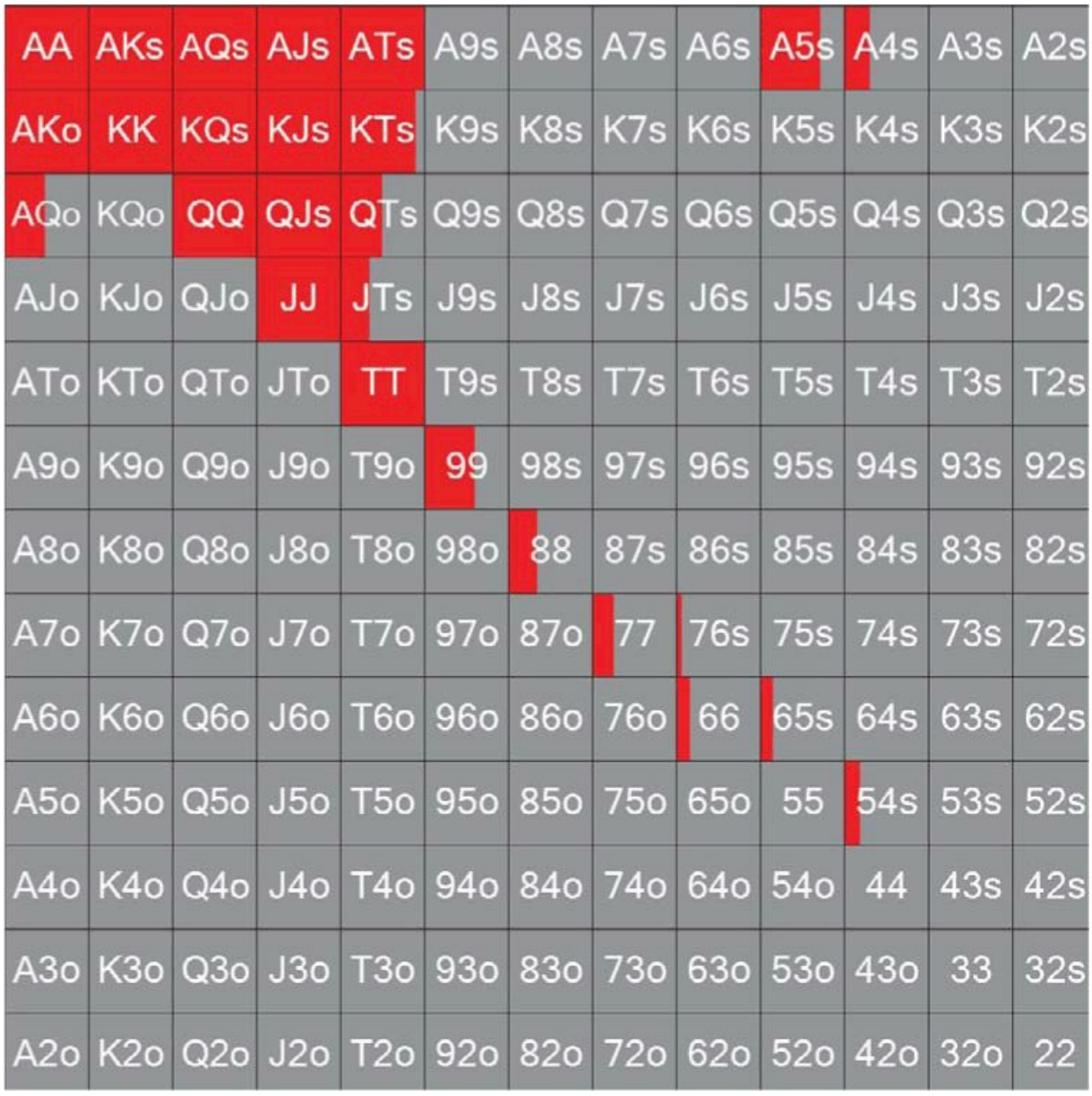
Hand Range 67: BN vs CO 4-bet
• 5-bet All-in 17.1% / • Call 45.2% / • Fold 37.3%

Small Blind

From the SB vs the LJ, you play a 3-bet or fold strategy similar to play from the HJ and CO, despite getting a discount on the call. Calling puts the SB in a bad situation where the BB remains active and can squeeze, forcing SB off their equity. Alternatively, the BB can call and realize their post-flop equity, capturing a portion of the pot. SB equity realization post-flop out of position against two players is quite bad, particularly with high SPRs. All of this, combined with

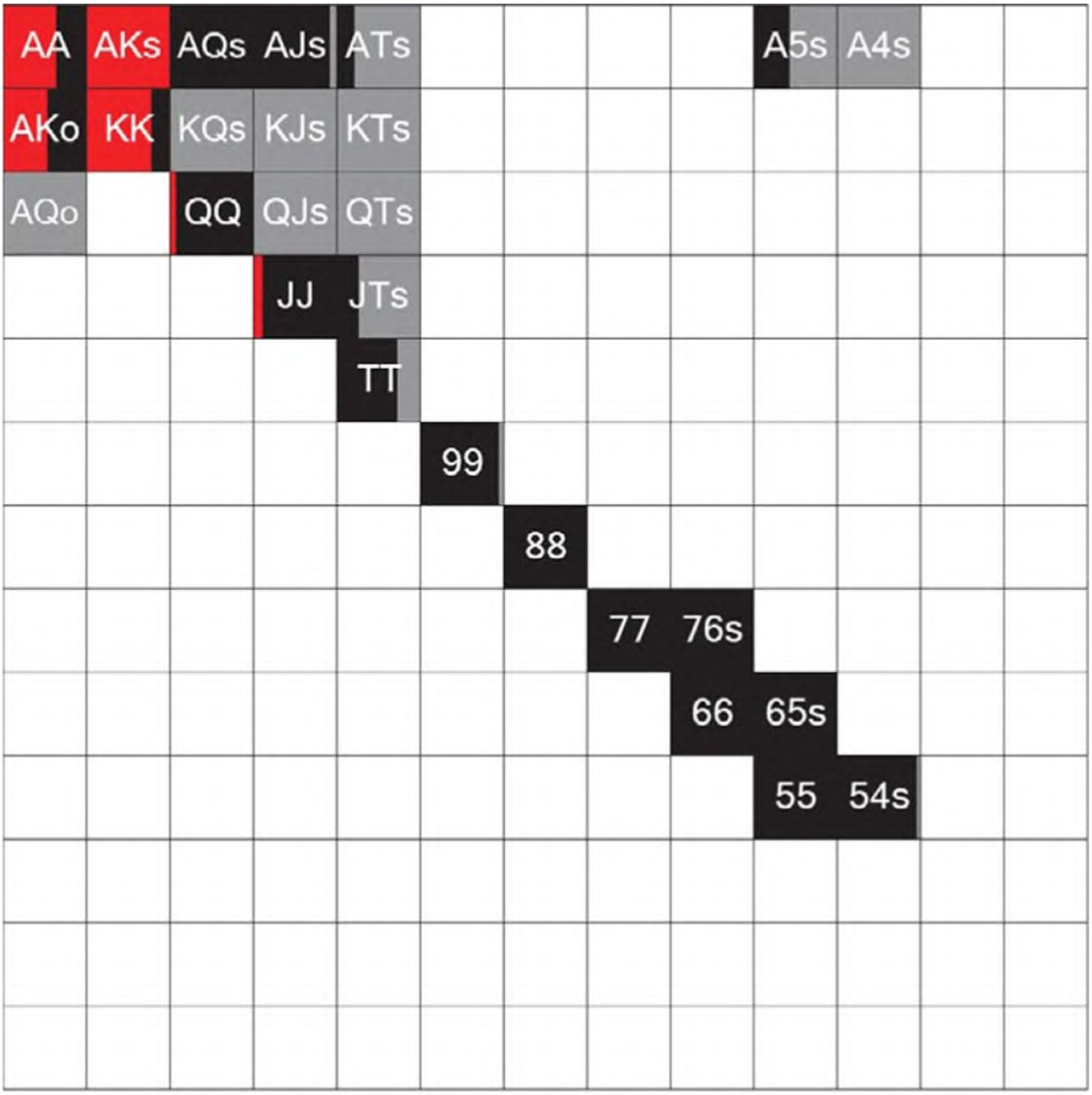
the effect of the rake, makes calling from the SB a losing proposition *(Hand Range 68)*.

In response to a 4-bet, a good 5-betting range is AKs, AA (63%), AKo (53%), QQ (7%) and JJ (10%). The calling range consists of all other pairs, suited connectors, AQs, AJs, ATs (21%) and A5s (44%). Small suited connectors and mid pocket pairs make better calls than hands such as AQo, Kxs, and Qxs because they unblock Villain's bluffs even if they have less raw equity *(Hand Range 69)*.



Hand Range 68: SB vs LJ Open

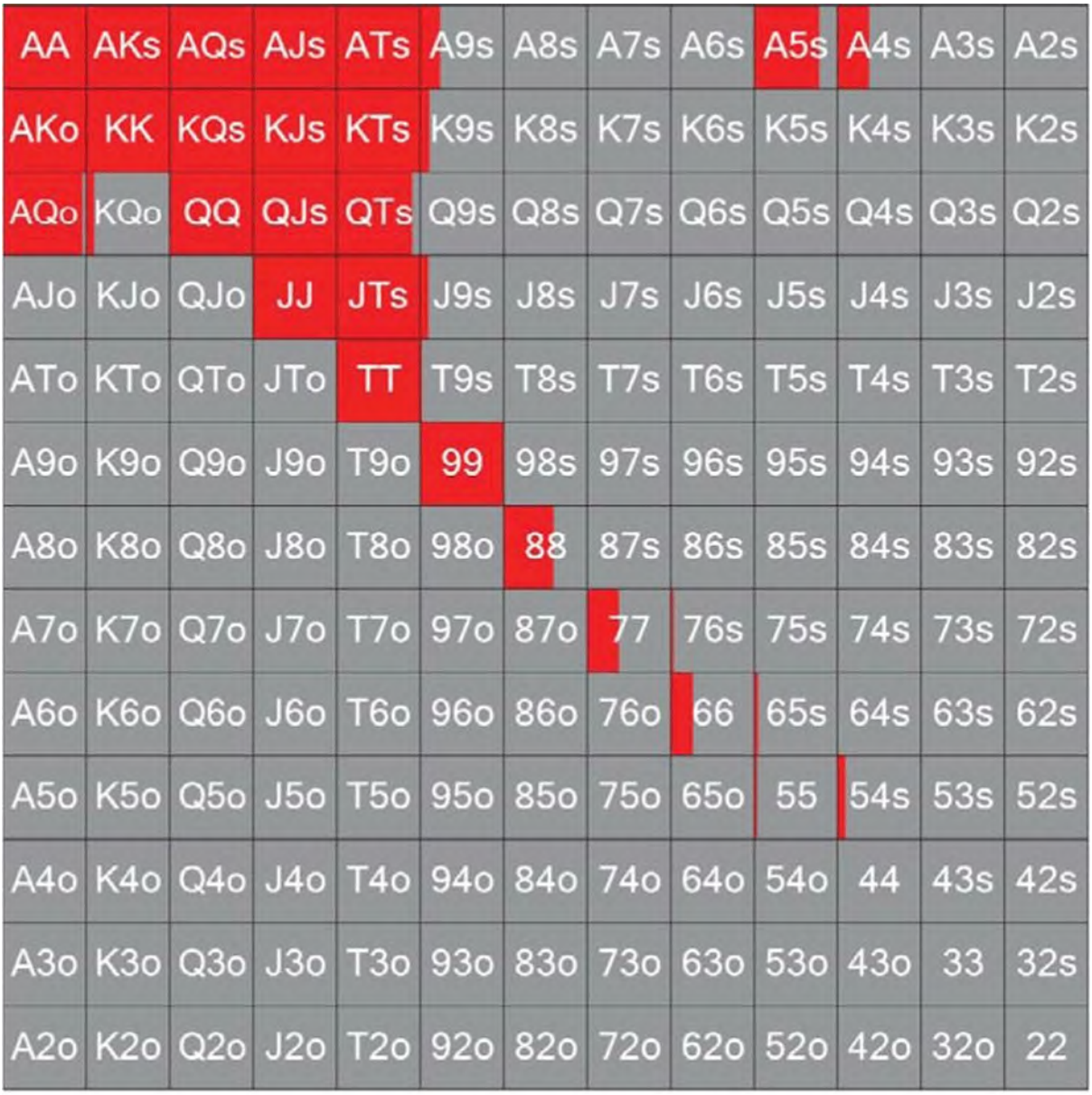
• 3-bet 7.3% / • Fold 92.7%



Hand Range 69: SB vs LJ 4-bet
• 5-bet All-in 20.6% / • Call 45.7% / • Fold 33.8%

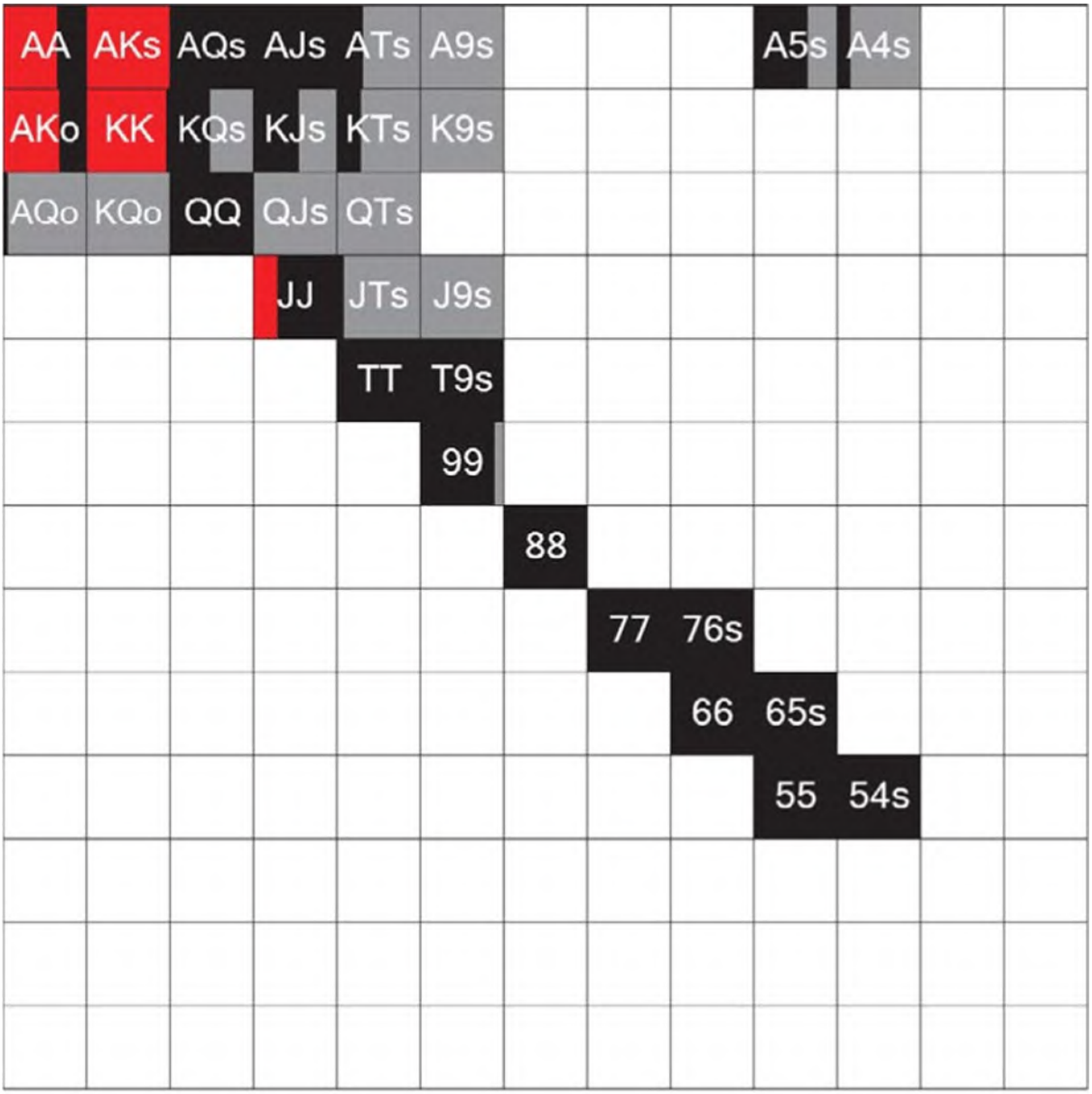
The SB can 3-bet a wider range vs the HJ than vs the LJ, incorporating hands such as A9s (23%), KQo (9%), K9s (10%), J9s (9%) and adding more weight to the threshold hands *(Hand Range 70)*.

Since you are 3-betting slightly wider vs the HJ than vs the LJ, you have to call a little more often vs the 4-bet to remain unexploitable by incorporating some calls with hands such as AQo (5%), KQs (48%), KJs (54%), and KTs (28%) *(Hand Range 71)*.



Hand Range 70: SB vs HJ Open

• 3-bet 8.7% / • Fold 91.3%

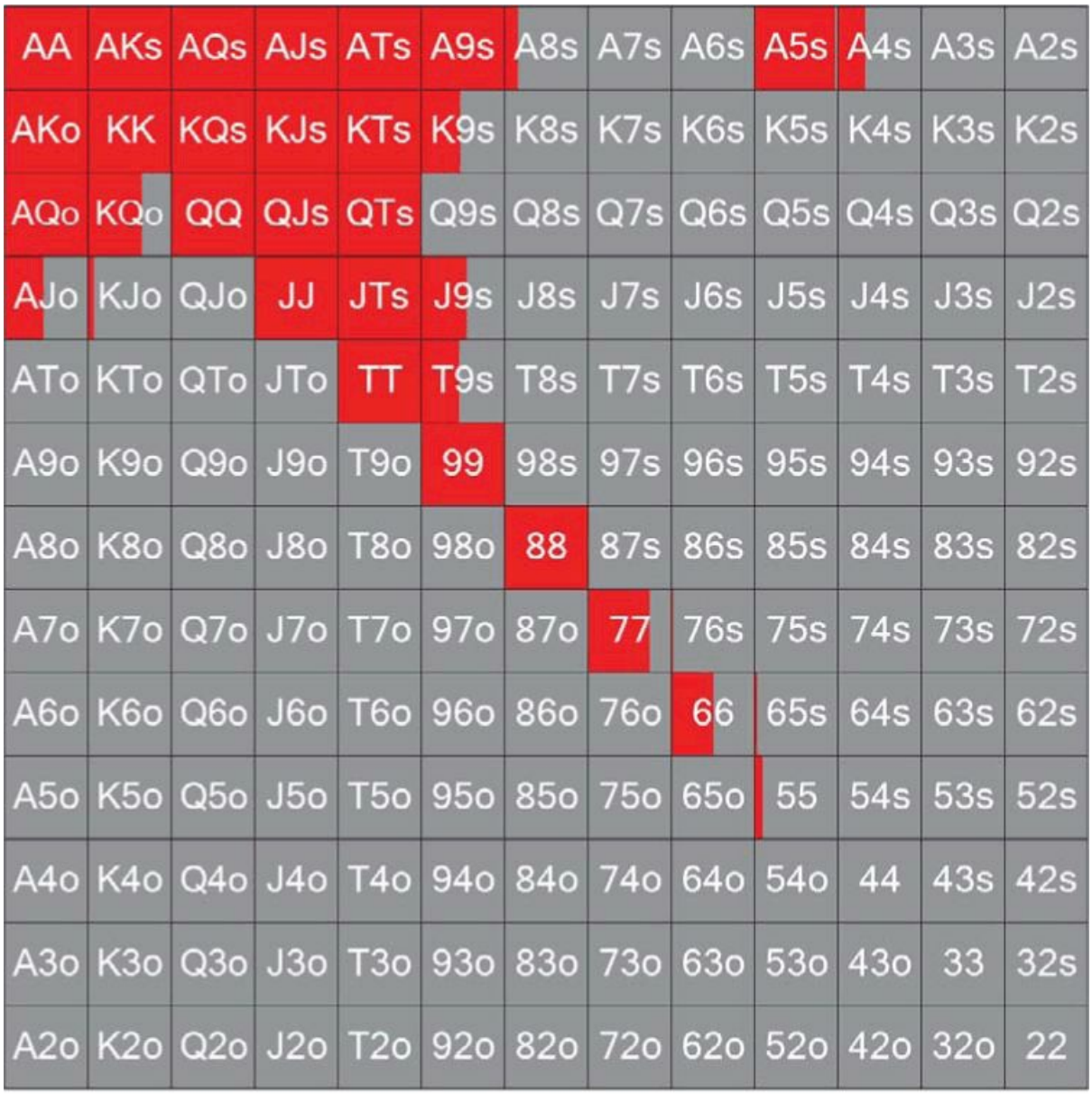


Hand Range 71: SB vs HJ 4-bet
• 5-bet All-in 20%% / • Call 46.8% / • Fold 32.8%

The SB can 3-bet 2.2% more hands vs the CO compared to the HJ by 3-betting hands such as AJo (47%), A8s (15%), T9s (45%) and adding more weight to the threshold hands *(Hand Range 72)*.

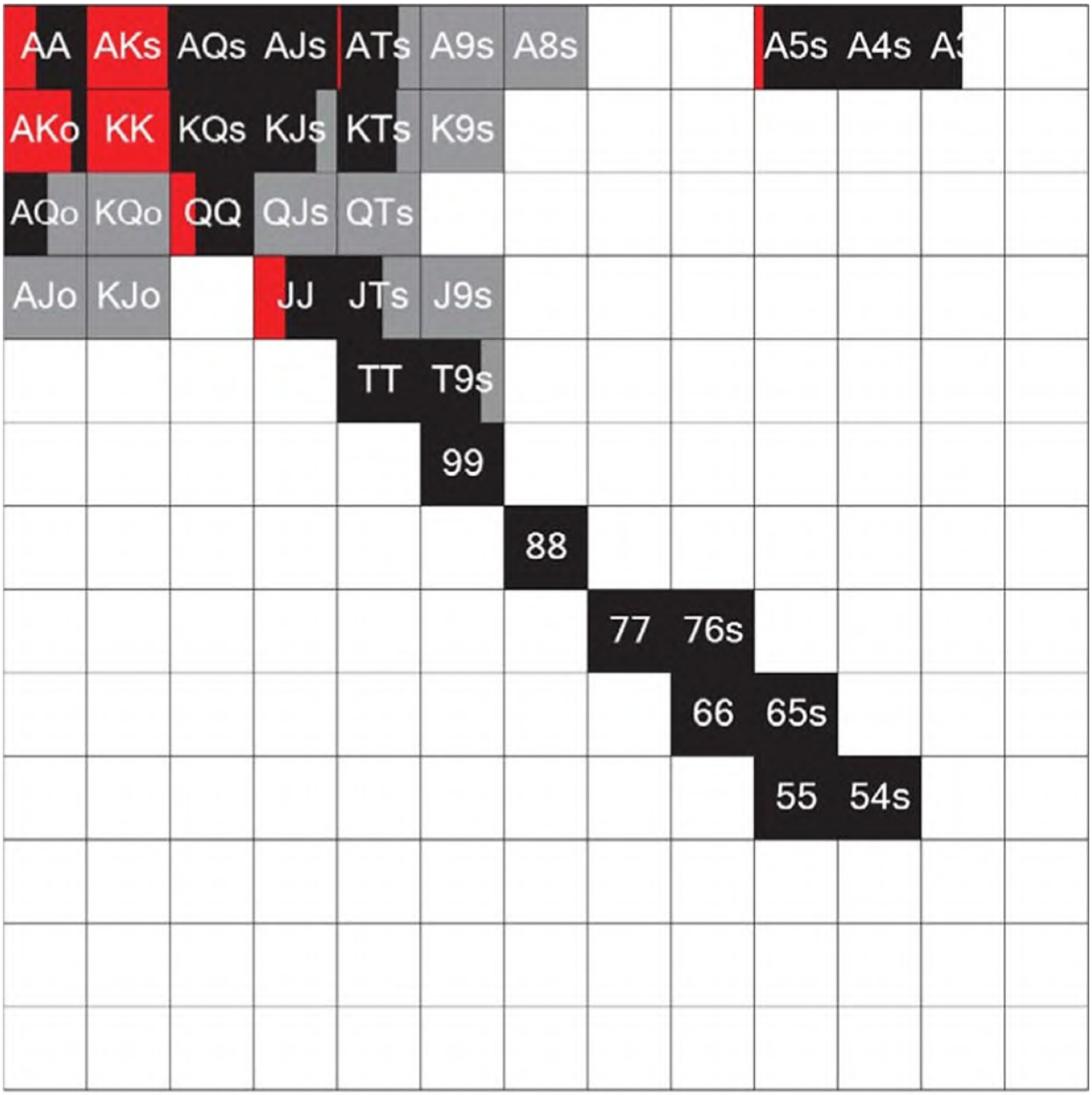
The SB should slowplay AA slightly more frequently vs the CO because the CO 4-betting range is more polarized than that of the HJ and the LJ, allowing you to call profitably with more hands such as AQo (52%), A3s, and JTs (55%). Suited wheel Ax hands make better calls than broadways and Ax with higher kickers such as A9s because they block AA and AK and unblock

bluffs such as KJs, KTs, K9s, J9s while retaining good post-flop playability. This is the point where, for the first time, we see a 5-betting range include some non-premium hands as bluffs such as ATs and A5s. The reason for this is that the EP and the MP 4-bet ranges are too strong and too blocker heavy. The LP 4-bet ranges vs the blinds are less centered around blockers and this starts to improve the EV of jamming these blocker-type hands. ATs and A5s are the highest equity bluff hands against very strong ranges *(Hand Range 73)*.



Hand Range 72: SB vs CO Open

• 3-bet 10.9% / • Fold 89.1%



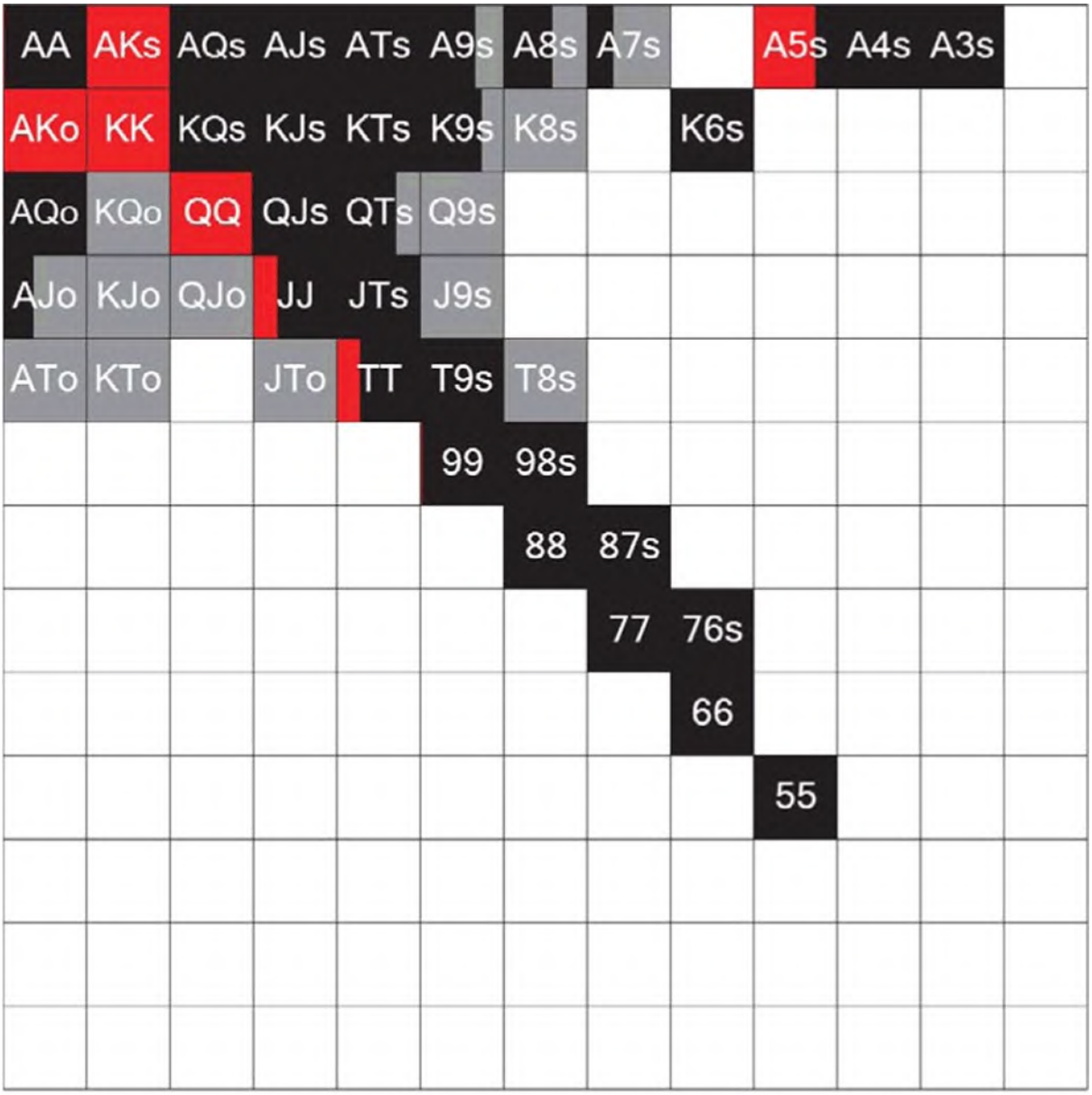
Hand Range 73: SB vs CO 4-bet
• 5-bet All-in 18.6% / • Call 52.2% / • Fold 29.2%

Against the BN, the SB can 3-bet 15% hands, adding hands such as ATo (43%), KTo (6%), QJo (3%), A7s, Q9s, T8s (71%), 98s (21%), 87s (9%), 76s (86%) as well as giving more weight to the threshold hands *(Hand Range 74)*.

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

Hand Range 74: SB vs BN Open

• 3-bet 15% / • Fold 85%



Hand Range 75: SB vs BN 4-bet
• 5-bet All-in 17.3% / • Call 56% / • Fold 26.5%

The BN 4-betting range is very polarized, so the SB is less incentivized to 5-bet and more incentivized to call, choosing to slowplay AA 100% of the time. The SB 5-betting range is KK, QQ, AK, JJ (29%), TT (27%), and A5s (74%), while the calling range is 55+, 76s+ AQo, ATs+, KTs+, A4s, A3s, AJo (37%), A9s (67%), A5s (74%), K9s (74%), QTs (72%), and K6s *(Hand Range 75)*.

Big Blind

Big blind defense strategies are probably the most important strategies to master, since most pots play out with someone raising and the BB defending. If you were to fold all of your hands from the BB, your Win Rate would be -100bb/100 from this position. Therefore, defending as many hands as possible in a profitable manner will help reduce the money you lose in the blinds, boosting your long-term winnings. Furthermore, if you fold too many hands from the BB, you quickly become a target for aggressive players looking to steal, whereas if you defend aggressively and play well post-flop, players will instead become wary of messing with your blinds. *Diagram 15* shows the frequencies with which the BB should defend.

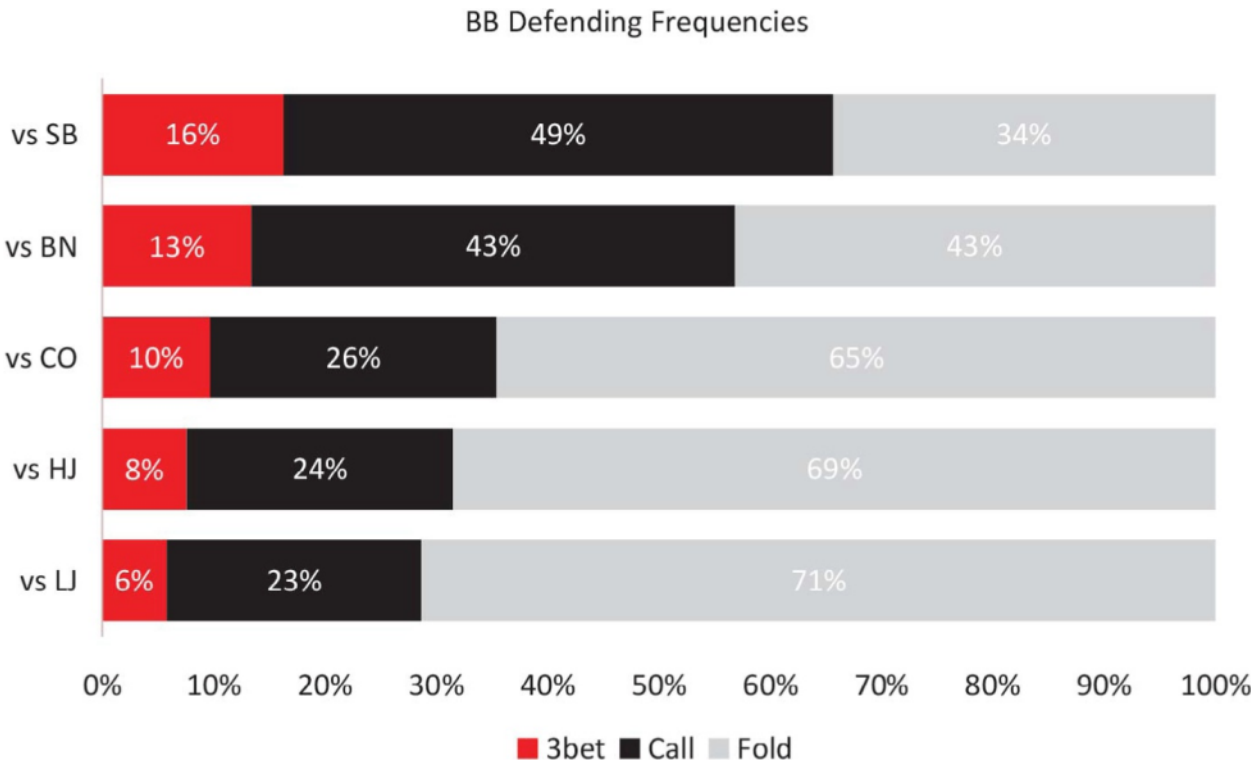
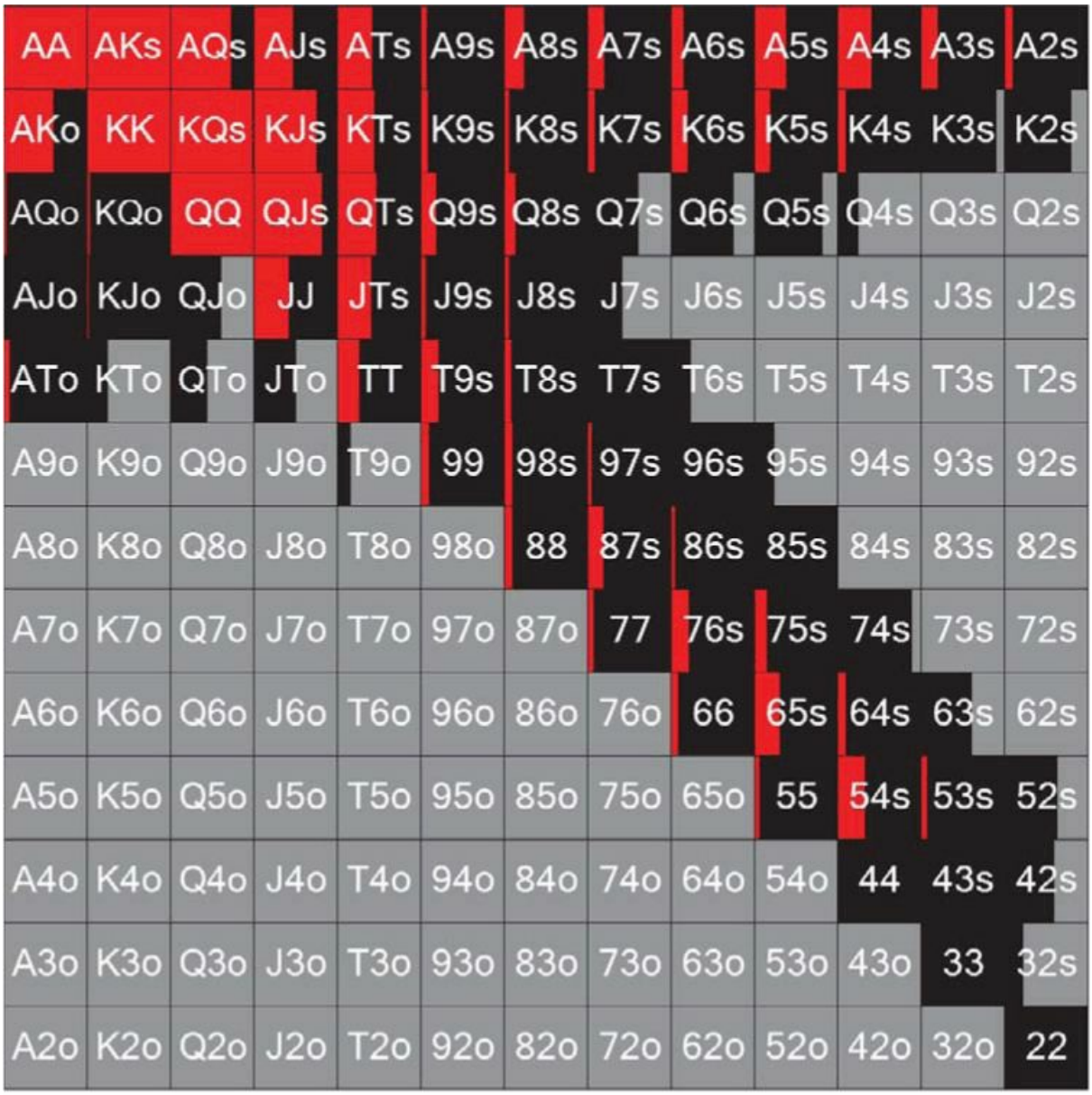


Diagram 15: BB Defending Frequencies

Against LJ opens, you need to defend tightly because the LJ opening range is quite strong. There are not many speculative hands that will have the right equity and equity realization to call profitably. Additionally, the LJ range can easily defend against 3-bets, so you can't go too crazy with 3-bet bluffs. Offsuit broadways such as AQo-ATo don't make good 3-bets because you are forced to fold them vs a 4-bet and their playability is generally poor in 3-bet pots, especially from out of position. On the other hand, suited broadways are great 3-betting hands, followed by suited Ax, Kx, suited connectors and suited gappers. The BB calling range consists mostly of the best offsuit broadways, all other pocket pairs, suited connectors, suited gappers, Axs and Kxs that are not 3-bet *(Hand Range 76)*.

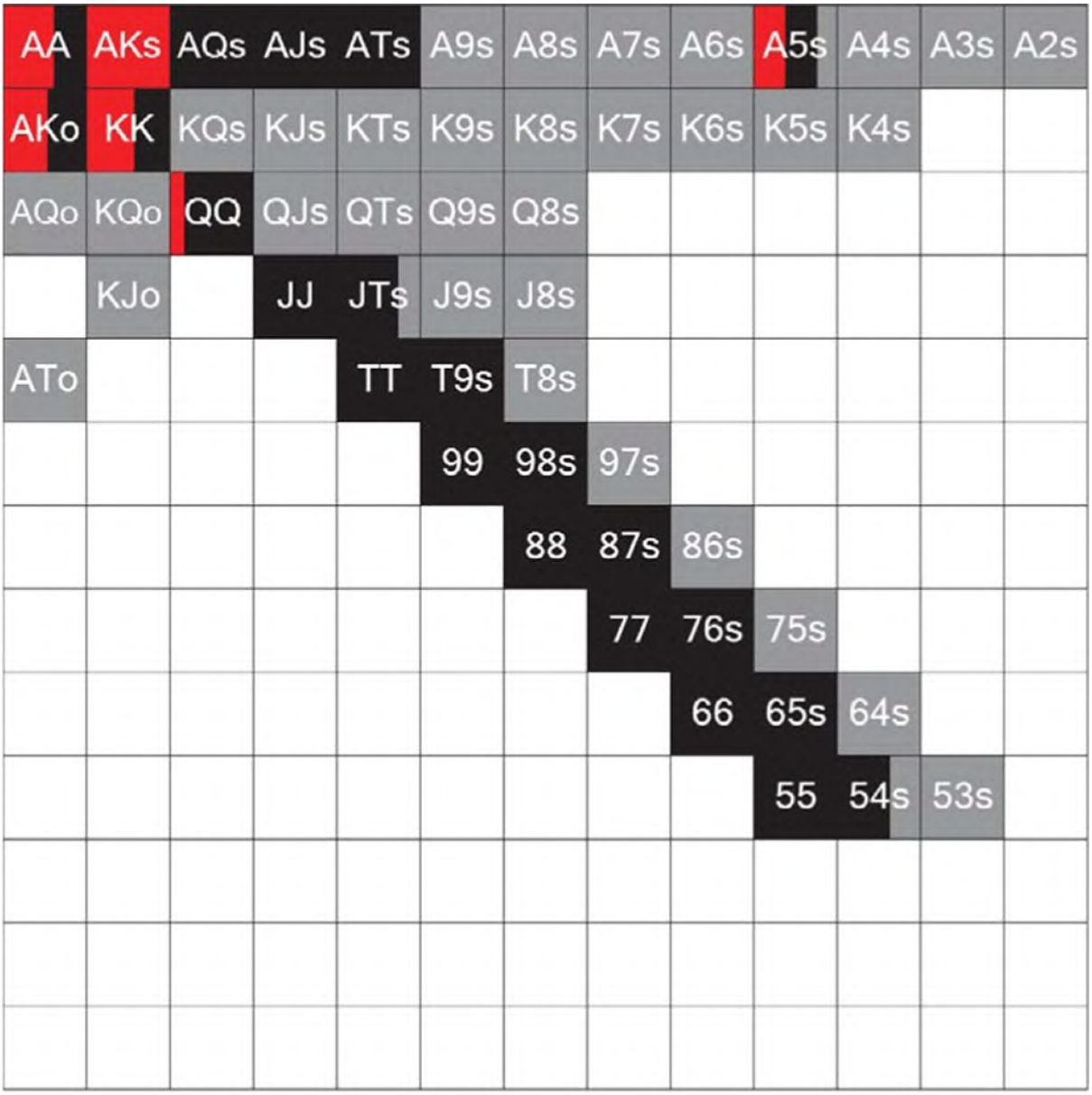
It may be surprising that hands as strong as A9o always get folded whereas hands such as K2s get called. The main reason for this is that offsuit disconnected hands tend to struggle to realize equity, particularly when playing against tight ranges.

When facing a LJ 4-bet, the BB 5-bets AA (61%), KK (57%), AKs, AKo (54%), QQ (16%) and A5s (38%) and can call all other pairs, ATs+, JTs (75%), T9s-65s, and 54s (64%) *(Hand Range 77)*.



Hand Range 76: BB vs LJ Open

• 3-bet 5.8% / • Call 22.8% / • Fold 71.2%

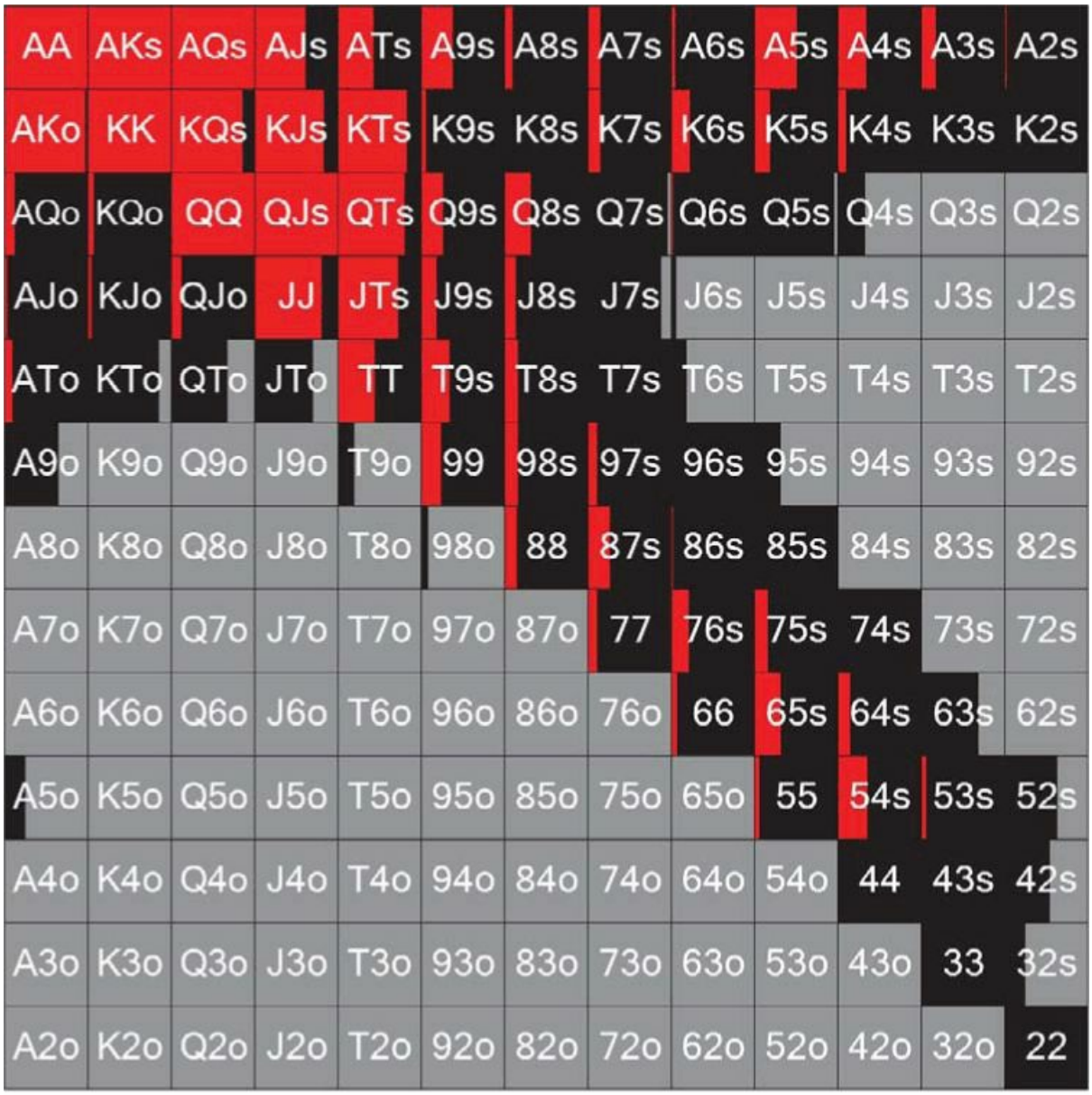


Hand Range 77: BB vs LJ 4-bet
• 5-bet All-in 21.4% / • Call 42.2% / • Fold 36.4%

Against HJ opens, the BB can defend a little wider than vs the CO and increase the 3-betting frequency by adding weight to the threshold hands *(Hand Range 78)*.

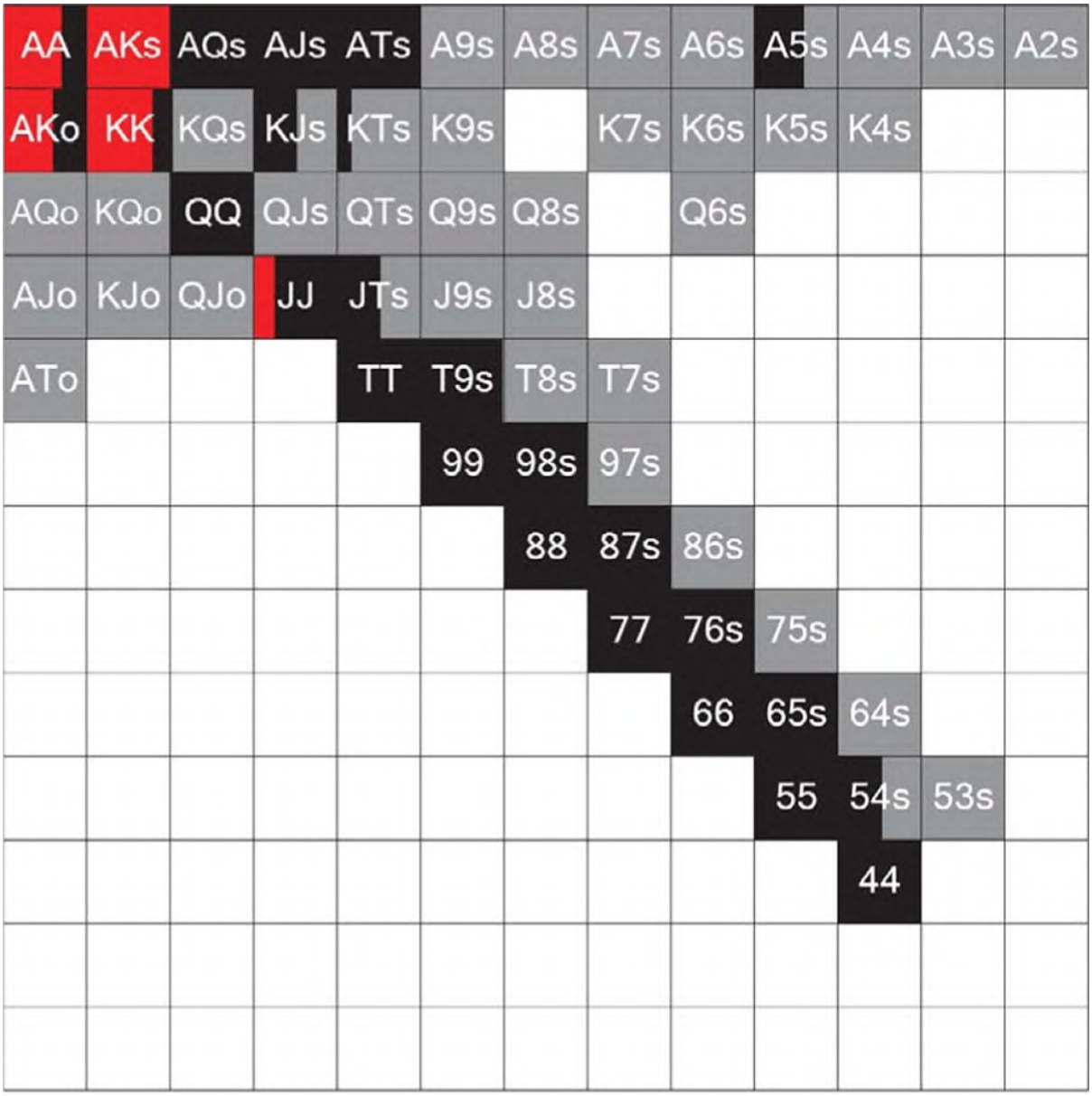
The BB response to a HJ 4-bet is similar to the response to the LJ. The main difference is that in order to maintain the proper defending frequency, you need to call a few more combos because the 3-betting range vs the HJ is slightly wider than vs the LJ. You expand your calls to include some hands such as KJs (52%), KTs (17%), while JJ gets 5-bet instead of QQ, probably due to some blocker effects, although, as mentioned previously, these small singularities are not

something that should be a huge concern for the reader. Again, the strategies presented are to help you develop a general idea of how to approach these common spots *(Hand Range 79)*.



Hand Range 78: BB vs HJ Open

• 3-bet 7.6% / • Call 23.9% / • Fold 68.5%

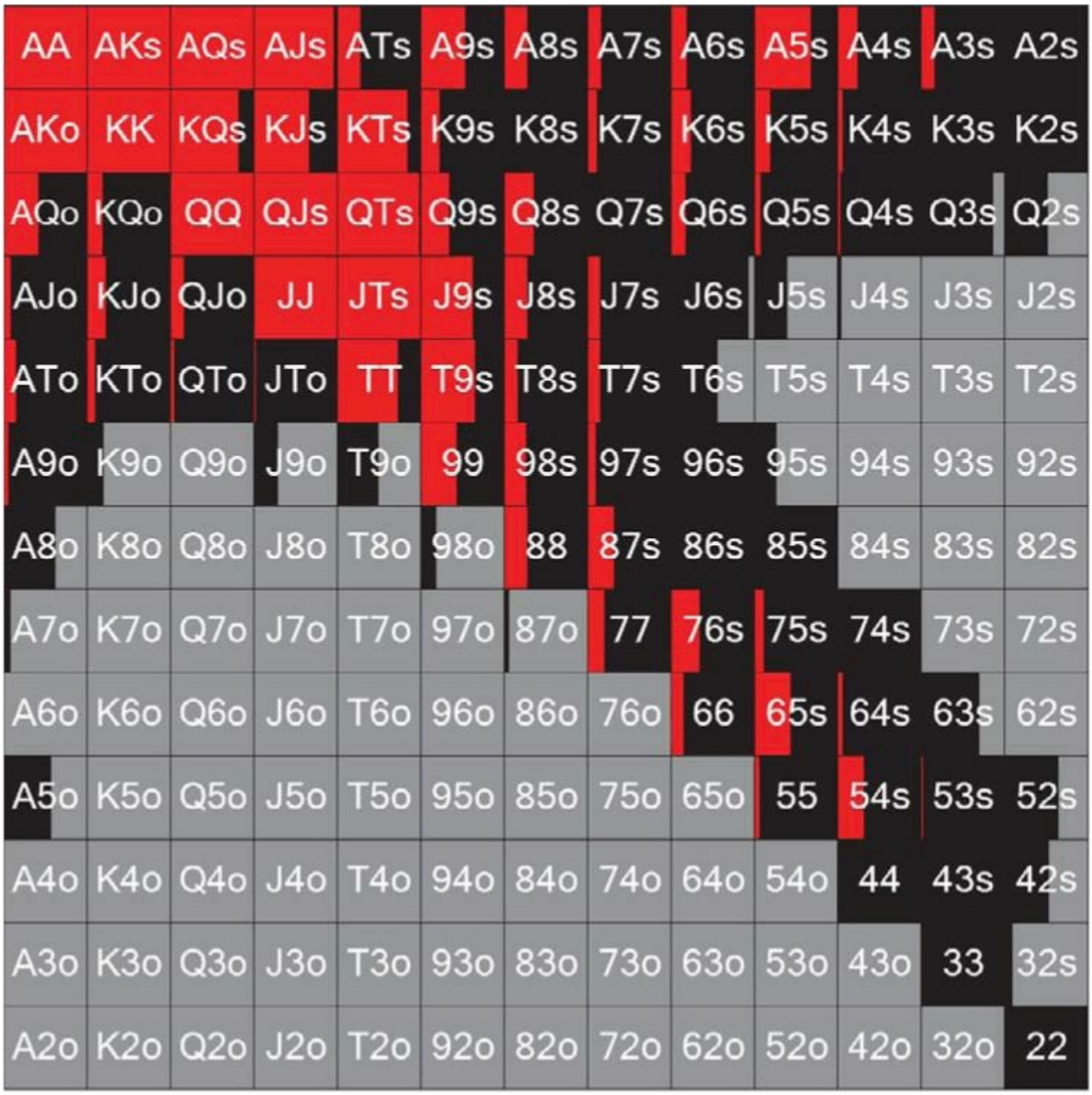


Hand Range 79: BB vs HJ 4-bet
• 5-bet All-in 21% / • Call 42.5% / • Fold 36.5%

Against the CO, the BB can defend 3.9% more hands. Both 3-bet and calling ranges get slightly wider by adding more weight to the threshold hands. It is worth noting how many offsuit hands such as K8o and Q9o simply get folded vs a CO open. As mentioned previously, offsuit hands with low connectivity struggle to realize equity post-flop OOP, especially with deep stacks *(Hand Range 80)*.

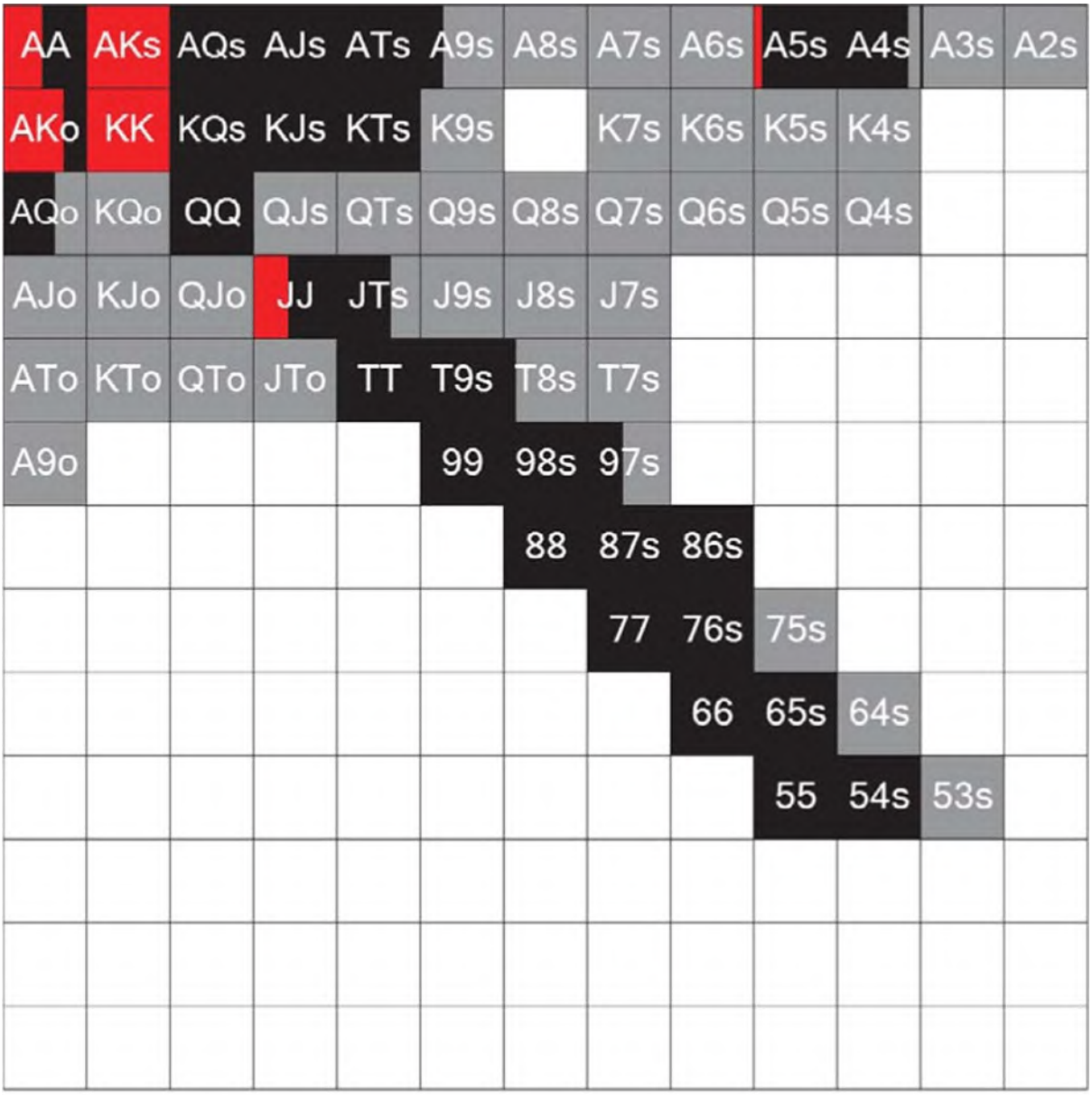
The CO 4-betting strategy vs the BB is a lot more polarized than the LJ and HJ strategy, so the BB responds by calling more hands and slowplaying AA slightly more often (53%). The BB

calling range gets expanded by incorporating more hands such as KQs, 44, AQo (62%), A5s, A9s (27%), and A4s (86%) *(Hand Range 81)*.



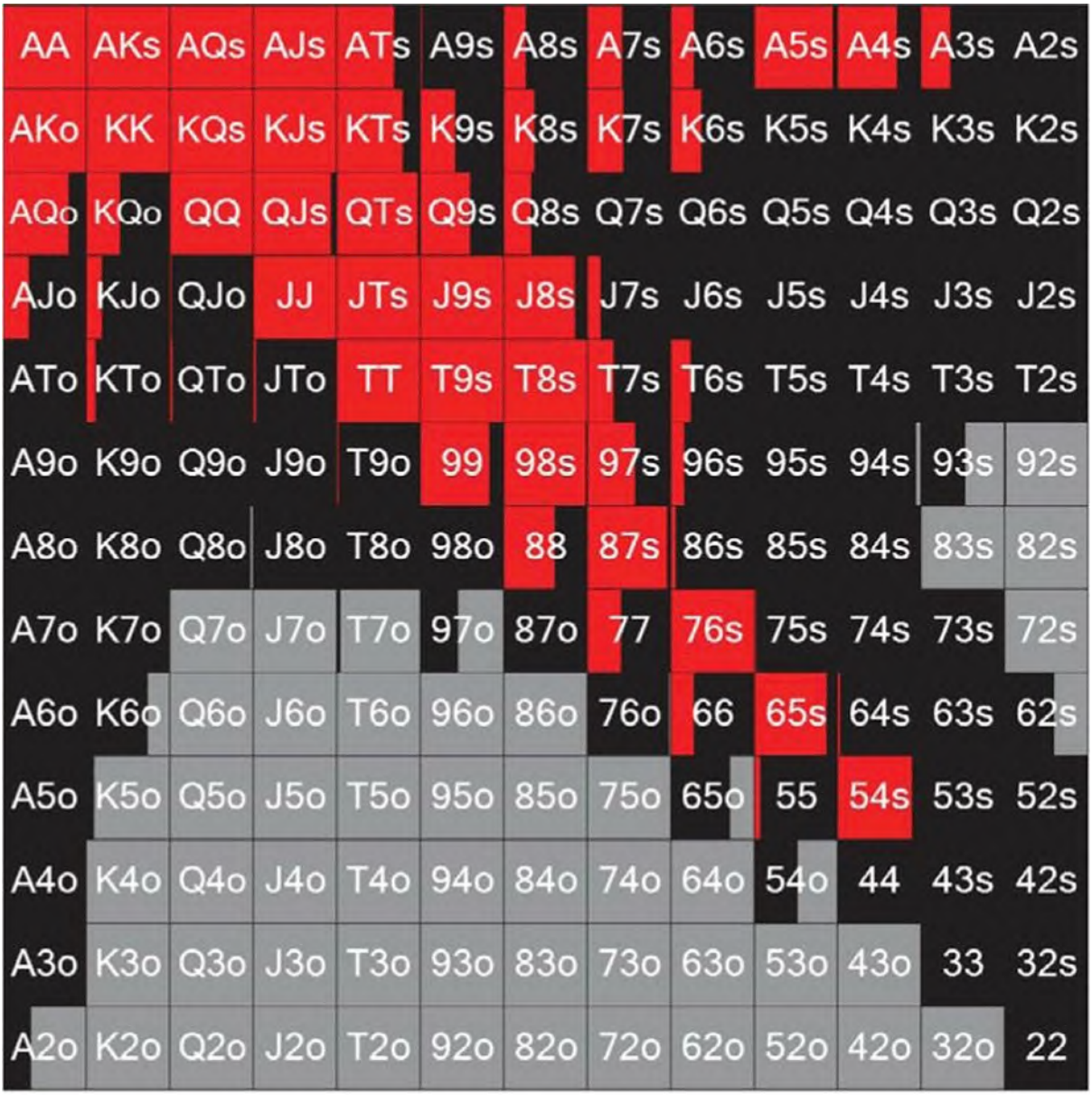
Hand Range 80: BB vs CO Open

• 3-bet 9.7% / • Call 25.7% / • Fold 64.6%



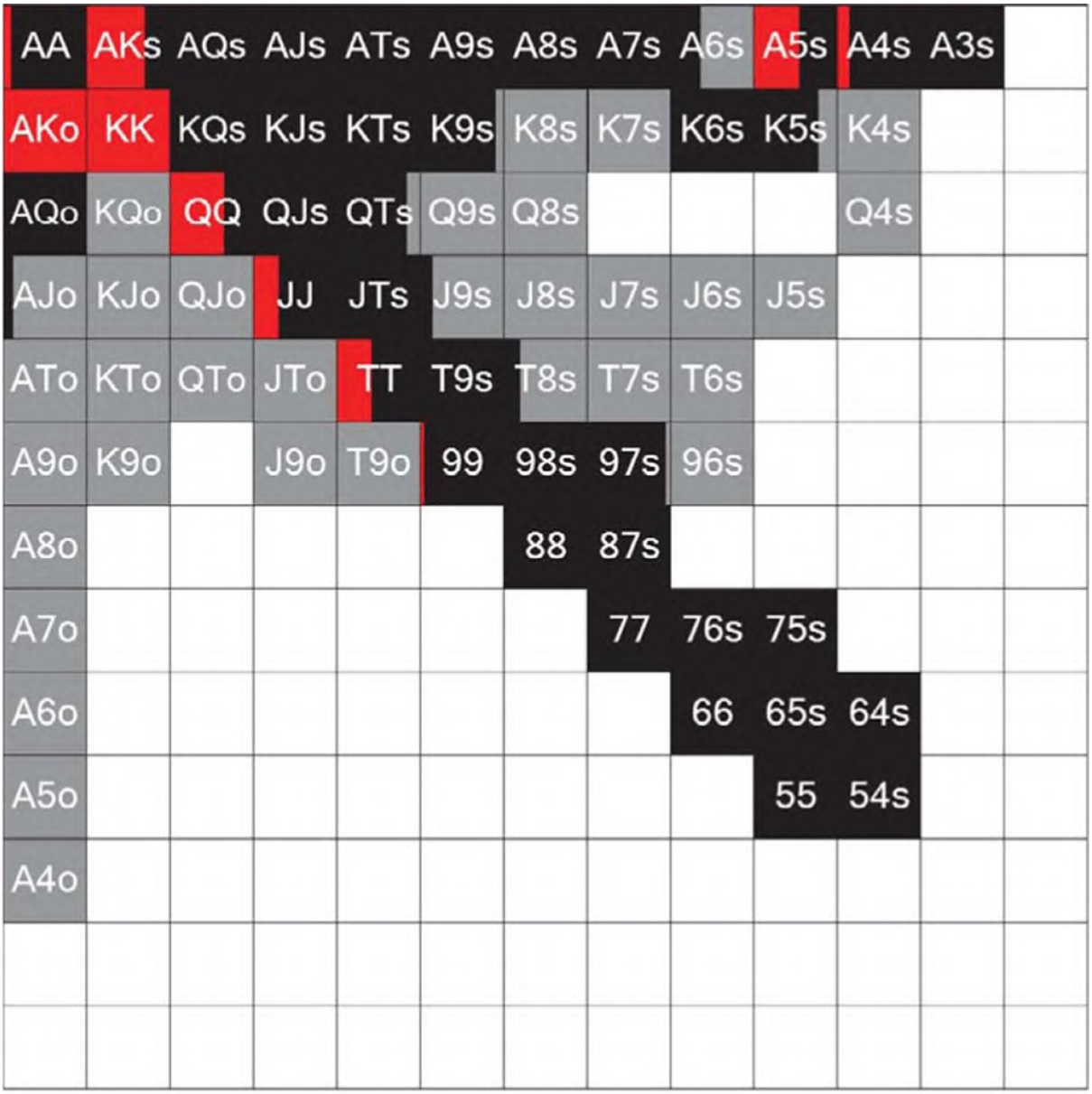
Hand Range 81: BB vs CO 4-bet
• 5-bet 18.8% / • Call 49.6% / • Fold 31.5%

Against the BN, the BB 3-bets a very linear range and plays in an overall more aggressive manner compared to the strategy employed when facing the earlier positions. The BB now 3-bets 13.4% hands while calling with most suited hands, offsuit Ax, connectors and broadways. The BN range is wide enough that now the BB can call many more hands compared to all the other positions, as the BN's ability to barrel and overbet very aggressively is downgraded due to the strong hands being diluted *(Hand Range 82)*.



Hand Range 82: BB vs BN Open

• 3-bet 13.4% / • Call 43.4% / • Fold 43.2%



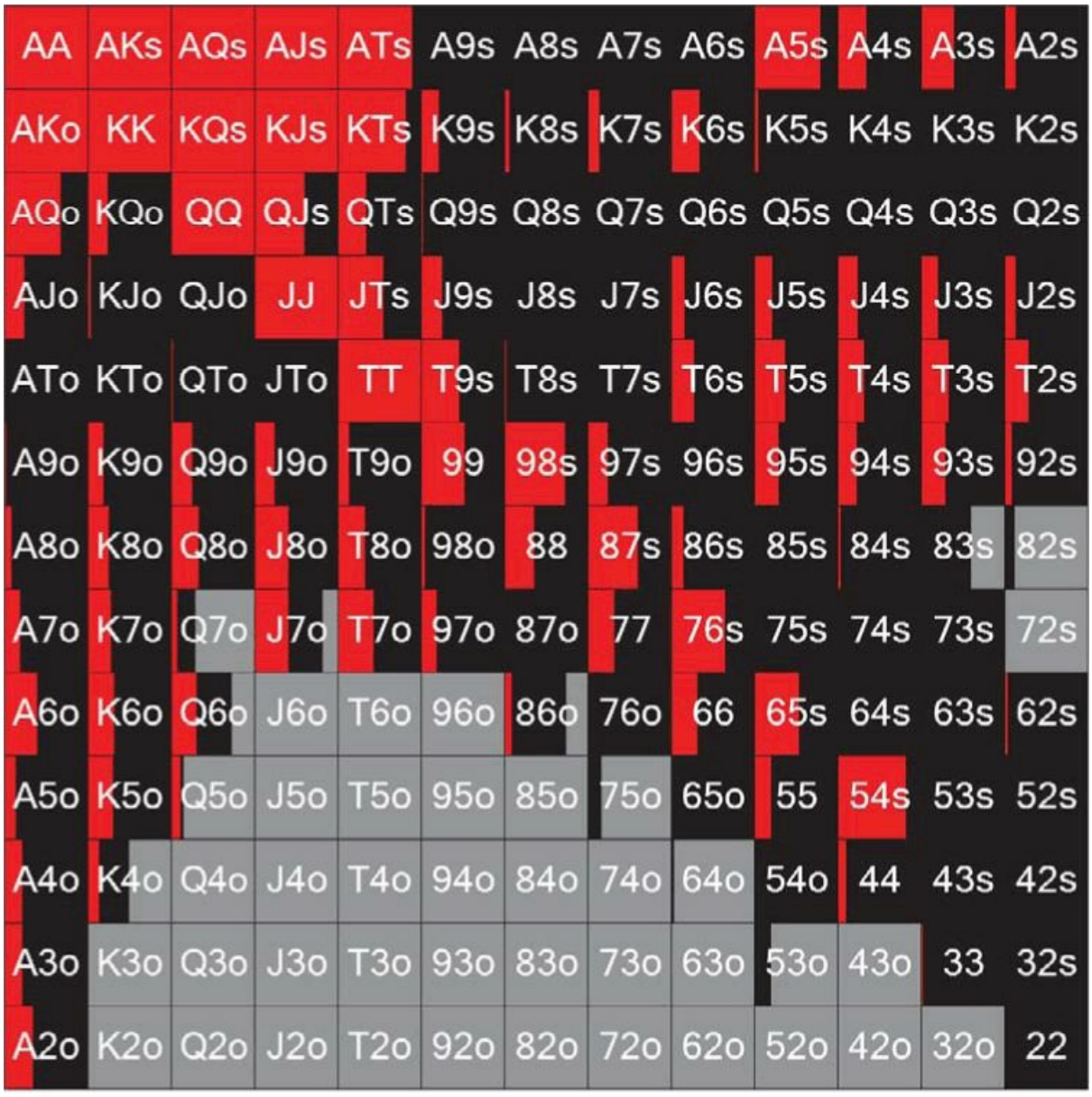
Hand Range 83: BB vs BN 4-bet

• 5-bet All-in 19.4% / • Call 54.1% / • Fold 26.5%

Against a BN 4-bet, the BB defends mostly by calling because the BN should be quite polarized. The BB 5-betting strategy involves jamming AA (32%), AK, KK, QQ (55%), JJ (32%), TT (31%), 99 (7%), A5s (45%), and A4s (43%). The calling range is expanded to include hands that have great equity and equity realization vs the BN 4-betting range, such as A7s+, K9s+, AQo, A5s-A3s, all suited connectors, and other pocket pairs *(Hand Range 83)*.

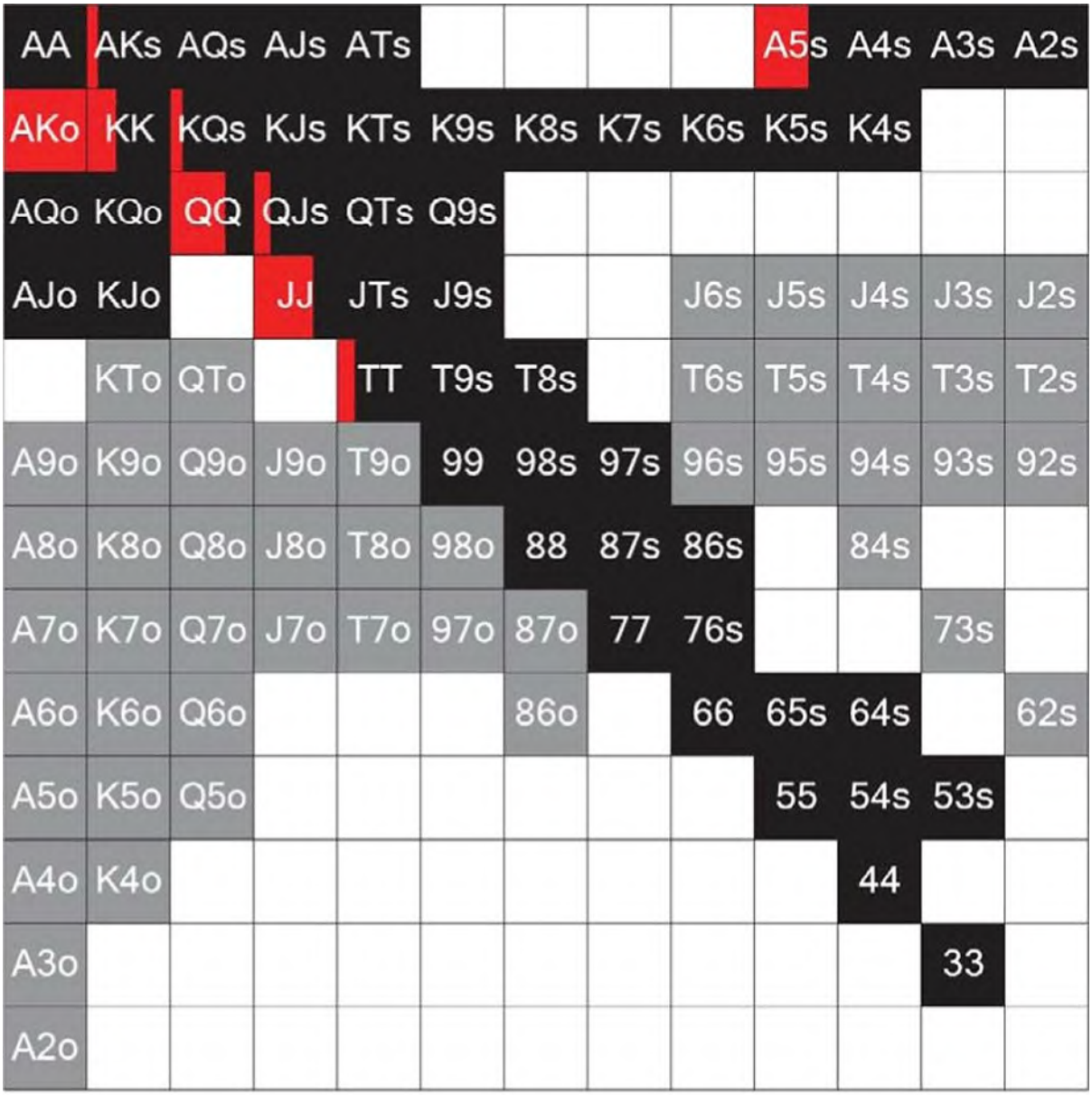
Due to being in position, the BB 3-betting strategy vs the SB open raise is very polarized, including the best hands that can either 5-bet jam or are happy to call 4-bets in position. The rest

of the range consists of hands that have good blockers and good board coverage that don't mind being folded to a 4-bet, such as Axo and K4o+. The BB flat calling range consists mostly of medium strength hands that can realize a lot of equity playing in position. The BB folding range is made up of the absolute worst hands that really get punished by rake, making it impossible to profit with them *(Hand Range 84)*.



Hand Range 84: BB vs SB Open

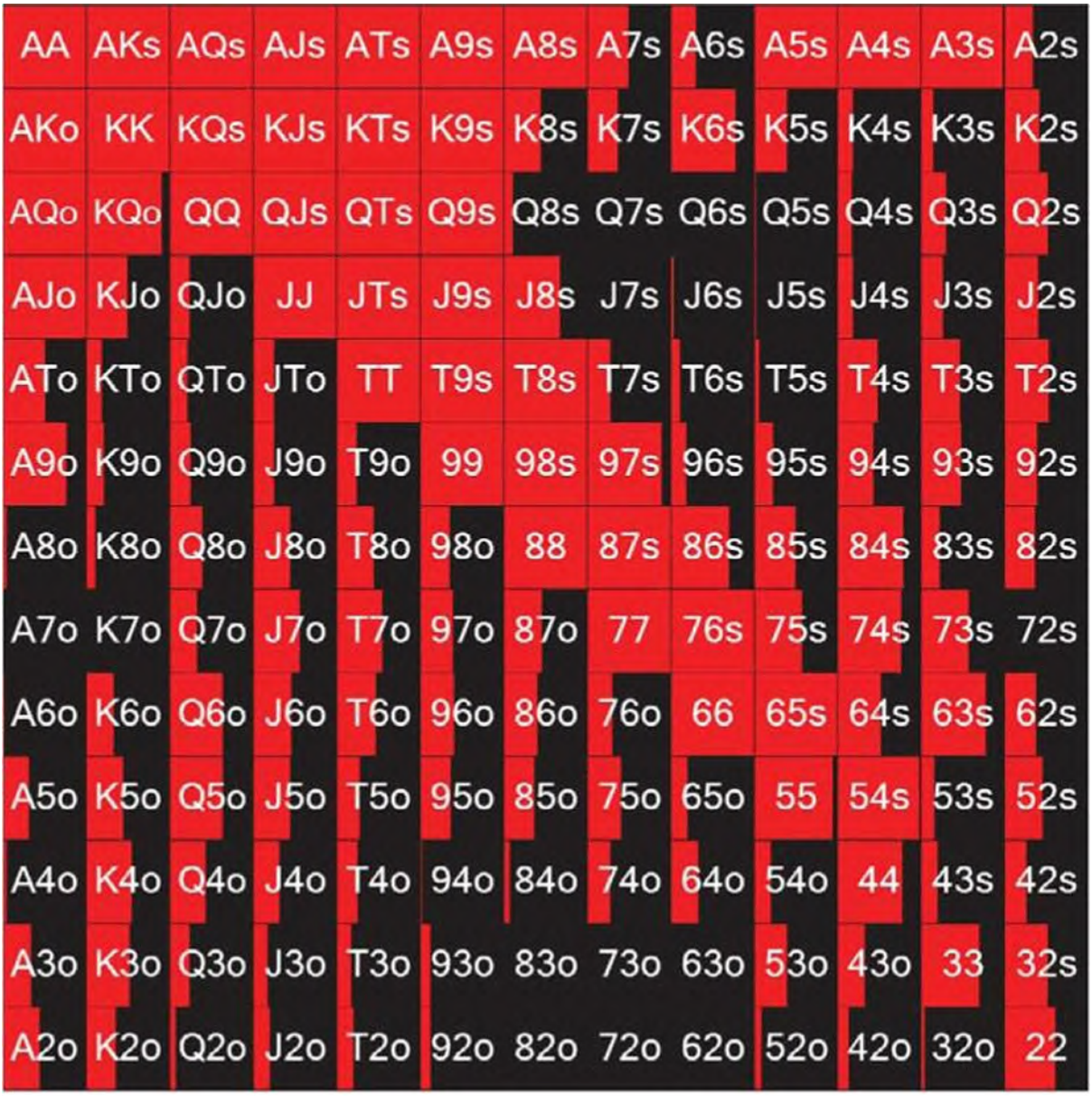
• 3-bet 16.3% / • Call 48.3% / • Fold 35.4%



Hand Range 85: BB vs SB 4-bet
• 5-bet All-in 12.6% / • Call 46.2% / • Fold 41.2%

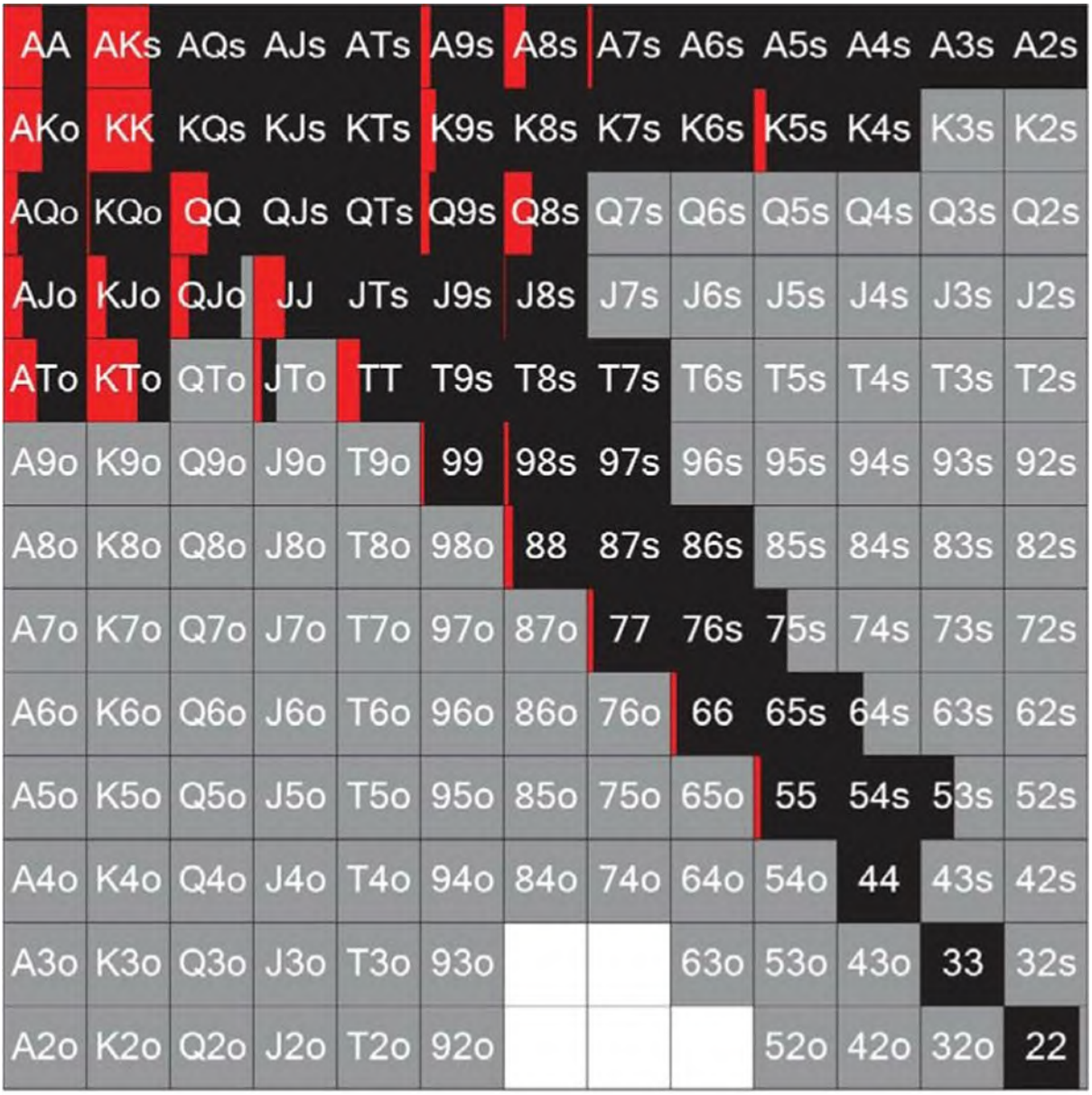
The SB 4-betting range is very polarized. Since the BB has position, the SB is incentivized to call many hands while 5-betting infrequently. They should slowplay hands such as AA (100%), KK (65%), QQ (34%), AKs (87%) and JJ (28%) and call all hands that have some playability. They should fold the bottom portion of their polar range *(Hand Range 85)*.

The BB wants to raise a semipolar range, with hands that can call in position vs a limp/raise and hands that are easy raise/folds. The BB will only 4-bet about 7% of hands, mixing up strong hands such as TT+, AK and some Ax and Kx blocker-type hands *(Hand Range 86-87)*.



Hand Range 86: BB vs SB Limp

• 3.5x 40.6% / • Check 59.4%



Hand Range 87: BB vs SB L/R

• 4-bet 7.3% / • Call 41.3% / • Fold 51.4%

06

THE THEORY OF

TOURNAMENT PLAY

While cash games and tournaments may appear similar, they are actually quite different. Cash games are generally played 6-handed with no antes and 100bb stacks, whereas multi-table tournaments are generally played 9-handed with antes and various stack sizes throughout the event. These factors, plus the difference in payment structure, make poker tournaments a completely different animal to cash games.

Variance

Variance is one of the most commonly-used terms in the poker world, yet most people don't fully understand it. In statistics, variance is a measure of how far a set of numbers are spread out from their average value. In poker, variance is a measure of how far actual results spread out from expectation (EV) *(Diagram 16)*.

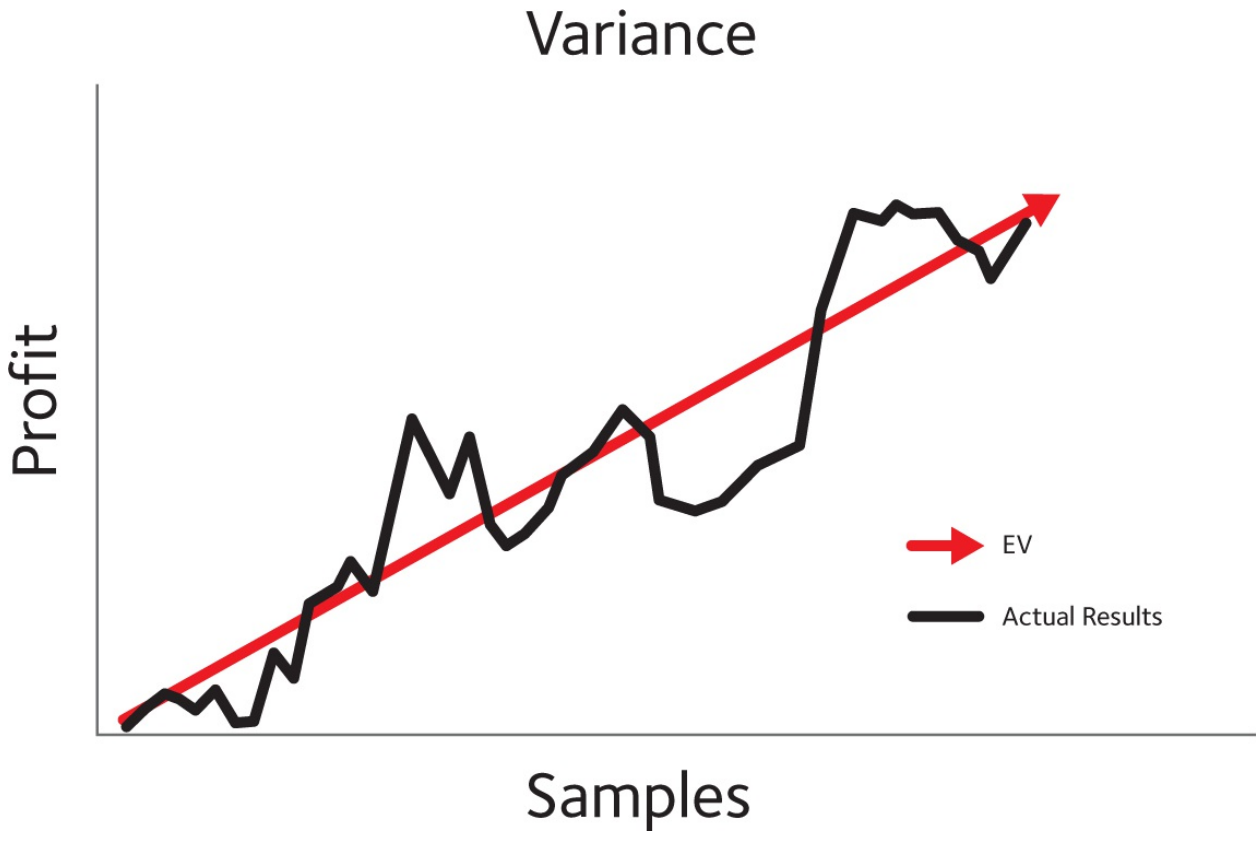


Diagram 16: Typical Variance Graph

Low variance means results are spread closer to the average and high variance means results are spread farther away from the average.

How is Variance Calculated?

If you use poker tracking software, it can report the standard deviation of your own results. Variance is simply the square of the standard deviation. If you know the standard deviation S, you can calculate the variance as follows:

$$Variance = S^2 = 5^2 = 25$$

Alternatively, it can be calculated by hand using this formula:

$$Variance = \frac{\sum(x_i - \bar{x})^2}{n-1}$$

Where:

$$x_i = Term\ in\ data\ set$$

$$\bar{x} = Sample\ average$$

$$n = Sample\ size$$

For example, in a small data sample with only three data points such as (1, 6, 11):

$$\bar{x} = \frac{(1+6+11)}{3} = \frac{18}{3} = 6$$

Then:

$$Variance = \frac{(1-6)^2 + (6-6)^2 + (11-6)^2}{3-1}$$

$$Variance = \frac{(-5)^2 + (0)^2 + (5)^2}{2}$$

$$Variance = \frac{25+25}{2} = 25$$

And the standard deviation S would be:

$$S = \sqrt[2]{Variance} = \sqrt[2]{25} = 5$$

Poker Applications

Let's say Hero has a sample of 100,000 poker hands played in online cash games. If you divide this sample into chunks of 100 hands each, you can calculate Hero's win rate on each chunk by simply adding the big blinds won and subtracting the big blinds lost by all 100 hands. This process will produce a total of 1,000 different win rates Hero experienced throughout the 100,000 hand sample. The more Hero's win rate varies in each chunk of 100 hands, the bigger the standard deviation will be.

Returning to the variance formula:

$$Variance = \frac{\sum(x_i - \bar{x})^2}{n-1}$$

$$x_i = The\ win\ rate\ on\ each\ one\ of\ the\ 100\ hand\ chunks$$

$$\bar{x} = Hero's\ average\ win\ rate\ over\ the\ 100k\ hands\ sample$$

$$n = Number\ of\ hands\ dealt = 100{,}000$$

We can see that the variance is affected by two main variables:

- ♦ The number of hands dealt. Since the number of hands is located in the denominator of the fraction, the conclusion is that the larger this number, the smaller the total variance will be, and the smaller the sample, the higher the variance. So, players who play a lot of volume will experience less variance than the occasional players.
- ♦ The spread of the win rates between each of the 100 hand chunks and Hero's average win rate. Since this number is located in the numerator of the fraction the conclusion is that the wider the spread, the higher the variance.

Different games and game formats will have a different spread between their actual win rates and the average win rate and therefore experience different variance and different standard deviation.

Game	Standard Deviation (bb/100)
NLH Full Ring	60-80
NLH 6-max	75-120
PLO Full Ring	100-140
PLO 6-max	120-160

Table 27: Standard Deviations in Different Games

The values in *Table 27* are according to the pokerdope.com variance calculator

Why is it Important to Understand Variance?

Understanding variance helps you to better interpret your poker results, estimate reasonable downswings, practice game selection and determine wise bankroll management.

As seen in Chapter 4, player win rates can be used to estimate earnings over a period of time, but that alone doesn't give the full picture. Because of variance, actual results often deviate from expectation, so we need a variance calculator such as pokerdope.com/poker-variance-calculator to be able to properly plan our games and bankroll in preparation for possible downswings.

Using the PokerDope variance calculator we can estimate how results may deviate from expectation, simulating two different NLH cash players over different hand samples *(Tables 28 and 29)*.

Simulated Hands	Standard Deviation (bb/100)	Win Rate Interval (bb/100)		Expected Winnings (in bb)	Worst Run (in bb)	Best Run (in bb)	Probability of Loss	Minimum BR (in bb)
		Worst	Best					
10	211.87	-421	426	0.25	-61	57	49.53%	2,690
100	67	-131	136	2.5	-227	218	48.51%	2,690
1,000	21.19	-40	45	25	-635	992	45.30%	2,690
10,000	6.7	-10.9	15.9	250	-1,852	2,112	35.45%	2,690
100,000	2.12	-1.74	6.74	2,500	-3,470	11,455	11.90%	2,690
1,000,000	0.67	1.16	3.84	25,000	5,433	43,579	0.01%	2,690

Table 28: Player A: Win Rate = 2.5bb/100

Simulated Hands	Standard Deviation (bb/100)	Win Rate Interval (bb/100)		Expected Winnings (in bb)	Worst Run (in bb)	Best Run (in bb)	Probability of Loss	Minimum BR (in bb)
		Worst	Best					
10	211.87	-419	429	0.5	-65	75	49.00%	1,345
100	67	-129	139	5	-200	199	47.03%	1,345
1,000	21.19	-16.19	26.19	50	-866	846	40.67%	1,345
10,000	6.7	-8.4	18.4	500	-1,830	2,394	22.77%	1,345
100,000	2.12	0.76	9.24	5,000	-3,544	12,082	0.91%	1,345
1,000,000	0.67	3.66	6.34	50,000	30,665	70,766	0.00%	1,345

Table 29: Player B: Win Rate = 5bb/100

Comparing both players results it can be confirmed that, as expected, the standard deviation decreases as we increase the sample. While having a higher win rate does not affect the standard deviation, it does reduce the probability of loss (going broke over the sample) very dramatically.

Variance in Tournaments

Some readers may have heard that poker tournaments have more variance than cash games, but why is that?

Tournament players are competing for a payout related to the position they finish in the tournament and thus tournament chips have no direct monetary value and cannot be cashed. So even if a player manages to accumulate a lot of tournament chips, there is no material gain unless

they can squeeze themselves into the positions that get paid, usually meaning the top 15-18% of the field. So, even if a tournament player has a high win rate of something like 10bb/100, contrary to cash games there is no way to know how much money they can make after playing some number of hands, or if they will make any money at all.

To understand why there is more variance in tournaments than in cash games we can consider a simple example. Suppose you lose a flip for 50bb in a cash game. It doesn't matter if you lost it at the beginning of your session or after 10 hours of play. You are still losing the same amount of money. Furthermore, in the cash game, you can always reload and get back to the exact same stack you had before you lost. In a tournament, if you lose a flip for 50bb after playing in an online tournament for 10 hours, it is not the same as losing the flip at the beginning of your session because, after 10 hours, you are going to be very close to the final table with over 90% of the field already eliminated. Your stack is worth way more than just your tournament entry, and if you bust or lose a substantial amount of your stack, you cannot simply reload and replay the same game and the same situation. Instead, you have to start over and, even after another 10 hours, you may not find yourself deep in another tournament in a similar situation. This results in the fact that losing a flip deep in a tournament may be worth hundreds of thousands of dollars in equity, which drastically increases variance.

Given that is the case, is there some way to reduce variance in tournaments? We will see…

Poker Tournament Metrics

A poker player's win rate is a measure of how good they are at making chips. This works very well in cash games because chips have direct monetary value, so a player with a higher win rate than another player at the same games can be said to be better. Or, at the very least, they can be expected to make more money in the long run. However, in tournaments there is no direct correlation, so a player with a high win rate can make less money than a player with a lower win rate. So having a high win rate in tournaments tells us how good the player is at accumulating chips, but not necessarily how good they are at winning money.

Therefore, for measuring a tournament player's skill we need a different set of metrics. For online players, it is easy to track results because websites such as www.sharkscope.com keep track of all the tournaments played at the most popular sites and offer many very useful metrics. For live players, it is more difficult to get an idea of real skill, as the sample of games played is smaller, and the only metric that is often recorded is total earnings.

Total Cashes/Earnings

This is by far the most famous metric in the poker world, although not as important in itself as people often think. This is because you should deduct from this number all the expenses, losses and taxes to really know how much money a poker player is up. For example, if a player cashes for $100,000 during a tournament series such as the World Series of Poker (WSOP) but spent $60,000 in tournaments buy-ins without cashing and had $20,000 in traveling expenses, they would only profit $20,000 (and that is pre-tax). Of course, cashes are important because clearly a player who never cashes can't be a winner, but this metric by itself isn't enough to measure skill level.

Profit

Profit refers to the total money a player is up after deducting their loses. This number is significantly more valuable than total cashes. For example, if a player's total earnings are $2 million, but they have spent $3 million in tournament buy-ins, they are actually down $1 million. However, again, this number by itself can be misleading in relation to a player's skill. For example, a losing player can be down a lot of money over a long period of time but then get lucky in a very large tournament, resulting in a hefty lifetime profit.

In the Money% (ITM)

ITM is the frequency a player cashes and is in the money. For online MTTs, this number (excluding bounty tournaments) is usually around 15-18% for winning players. Lower than that generally means that players are way too active during money bubbles or overly aggressive in the early stages of the tournament. Conversely, a higher ITM generally indicates playing too passively during money bubbles and passing up on too many spots. Squeezing into the money in exchange for missing the opportunity to build a big stack is often detrimental. In live tournaments, ITM% is a lot higher than online because, as explained before, the games tend to be softer, and so some players can achieve an ITM% of 30-50%.

Total Return on Investment (ROI)

Total ROI is a more useful metric than Profit or Total Cashes, but can still be misleading if used in a vacuum.

For example, let's say a player plays 2,000 $109 online MTTs in one year, making the total cost of investment $218,000. If they cash for $300,000 with a profit of $82,000, the Total ROI would be:

$$Total\ ROI = \frac{Gain\ from\ Investment - Cost\ of\ Investment}{Cost\ of\ Investment}$$

$$Total\ ROI = \frac{\$300{,}000 - \$218{,}000}{\$218{,}000}$$

$$Total\ ROI = 37.6\%$$

Average ROI

Average ROI is calculated independently for each tournament played and then the results are averaged. This metric says a lot more than the other metrics about a player's skill relative to the fields they play

For example, let's say there is a particularly bad player who plays a total of 1,999 $109 online MTTs during a year and he loses all of them. So, they decide to take a shot at a large-field $1,050 event and get first place for $300k.

Now let's think of a different type of player who has consistently won in the $109 tournaments with several final deep runs and final tables. After playing 1,999 games they are up $301,050 and so also decide to play the large-field $1,050 event. However, they suffer a bad beat and don't even cash. So, their winnings after 2,000 games are $300k.

If we calculate both players' Total ROI, the result would be the exact same for both the good player and the bad player who got lucky:

$$Total\ ROI = \frac{Gain\ from\ Investment - Cost\ of\ Investment}{Cost\ of\ Investment}$$

$$Total\ ROI = \frac{\$300{,}000 - (\$217{,}891 + \$1{,}050)}{\$218{,}941}$$

$$Total\ ROI = 37\%$$

However, if we calculate the Average ROI for the bad player, we get a very different result:

$$Avg\ ROI = \frac{\left(1999 * \frac{(0-109)}{109}\right) + \left(\frac{(300000-1050)}{1050}\right)}{2000}$$

$$Avg\ ROI = \frac{-1999 + 285}{2000}$$

$$Avg\ ROI = -0.857$$

$$Avg\ ROI = -85.7\%$$

By analyzing a player's Average ROI, we can get a better understanding of whether they are actually beating poker in the long term. The previous example is, of course, extreme as even the worst players will cash some of their tournaments, get deep and make final tables with some frequency, but it illustrated the point.

However, having a high Average ROI doesn't guarantee a player will make money after playing a number of games and, also as we saw, having a negative Average ROI doesn't guarantee a player will lose money after playing a number of games. This is due to the high variance inherent to MTTs.

Decreasing Variance and Increasing Profitability in MTTs

The two main ways of decreasing variance while increasing your profitability in MTTs are to increase your Average ROI and to increase your volume. First, you should focus on increasing your Average ROI because it's pointless to put in a lot of volume if you can't even beat the games, so you should only increase your volume once you are certain you can beat the games you want to play.

Another way to increase profitability is to play higher stakes, although this will also increase your variance because, in general, the higher the stakes, the tougher the games. So, you can expect your ROI to be reduced as you move up in stakes. Also, there aren't nearly as many high stakes online tournaments as there are low-mid stakes tournaments, so the volume a high stakes

online MTT player can put in on a yearly basis is limited and that increases variance. Playing fast/turbo tournaments can help increase volume, but the possible ROI in them is also lower than regular-speed games due to having less time to extract value from weaker opponents, with most of the play taking place pre-flop with shallow stacks. Bounty tournaments are good to reduce variance, but your EV in them is lower than regular MTTs because a portion of the prize pool is taken away for the bounties, and weaker players, who are less likely to win the tournaments, will capture some of that bounty pool by knocking out some players before busting. On the other hand, for these same reasons, bounty tournaments favor weaker players.

Increasing Your Volume

Live MTTs are particularly attractive as they offer higher ROIs than their similar buy-in online counterparts due to the softer fields. However, at the same time, variance is a lot higher in live MTTs compared to online because of the low volume. So, a good way to increase your volume is to play online poker (assuming online players play multiple tables and, in general, more games than live players).

For new players, I recommend a ratio of 50% play time and 50% study time. Gaining in-game experience is vitally important because there are many aspects of poker that can really only be learned by playing. So, for new players, volume isn't about making money, but instead about getting proficient with the practical and theoretical aspects of the game and so the focus should be on study. However, for winning players I recommend a ratio of 80% play time and 20% study time. After a player's ROI is high enough, putting in a lot of study time won't have a high impact on their bottom line but, at the same time, if a player completely stops studying, their poker skills will stagnate while their opponents keep improving. Slowly but surely, they will become worse relative to the field, thus the need to continuously improve. My personal ratio for the last few years has been the opposite, 20% play time and 80% study time, which is not something I'd recommend to people who like winning money! I just happen to enjoy coaching and theory work, such as writing GTO books and articles, a lot more than I enjoy playing. Still, I plan on putting in a lot more volume in the near future, playing both live and online tournaments, as well as cash games.

Increasing Your ROI

The easiest way to increase your ROI is to play lower stakes which implies playing against worse opponents. The toughest way is to become better than your opposition. The tricky part is figuring out how to actually do it.

The first thing to do is to make sure you can win chips from your opponents. It's tough to get deep in tournaments if you can't accumulate chips by constantly making +EV decisions, so you need to know how to play the game well, which means learning about pre-flop and post-flop strategies at different stack depths, pot odds, equity and all the other concepts discussed in this book. However, as mentioned before, succeeding at tournaments requires more than simply being able to accumulate chips.

Tournaments are more of an art than a science. I have often seen cash game players talk down to top MTT players and even call them names such as "donkament players" and yet these same cash players are unable to thrive in MTTs themselves. Even I am guilty of having done this in the past, thinking that all that was required to crush the games was to learn GTO and that was the main reason I got so involved in poker theory in the first place. Of course, being a GTO wizard helps to play better poker, but there are a number of soft skills that top MTT players need to develop in order to succeed. These include the understanding of tournament life, money bubbles, the way the different stages of the tournament change equilibrium strategies, a deep understanding of population tendencies, not to mention live reads, tells, bankroll management and mental game.

It was while writing this book that I found the most important game theory concept and I'll share it with you now

> *GTO poker is not about balance, it is about exploitation. Equilibrium strategies arise when two players are maximally exploiting each other, thus there is no need for balance when your opponents are unaware of what you are doing or are incapable of counter-exploiting you even if they knew exactly what you are up to.*

Even though this realization might seem superfluous, fully understanding this concept helped me change my mindset at its core. I used to try to play good poker, to play well. Now I'm just trying to run over my opponents. Tournament poker is all about exploitative play, and this is why guys like Daniel Negreanu and Phil Hellmuth are among the most successful tournament players in poker history, even though they are not necessarily the most versed in poker theory. Daniel can talk his opponents into checking down AA on Qxx when he holds top pair and Hellmuth can fold AK pre-flop vs AA from a short stack while later running a crazy bluff against Jungleman, making him fold trips and giving him the *King of the Hill* title.

This is also the reason why Fedor Holz took the world by storm, winning all the high rollers and super high rollers before retiring to pursue other ventures. He said in an interview that he doesn't think he is particularly talented at poker but he surrounded himself with very smart people and he became part of a great community that helped him improve his technical skills.

What makes him different from other players in the German team is his ability to put the theory into practice, to adapt more optimally than his opponents and to exploit weaknesses.

The GTO principles and strategies discussed in this book can help players improve their game, avoid fundamental mistakes and make better decisions. However, there is more to winning in poker than just playing well. So, my advice to increase your ROI is to study poker theory but also focus on how to put it into practice. Study your opponents and never be afraid of making a bad play or looking stupid, just like Daniel, Phil and Fedor aren't afraid to, even when playing the biggest games when the whole world is watching.

Understanding Tournament Metrics and Results

Table 30 uses the pokerdope.com Tournament Variance Calculator to simulate the results of players with different average ROIs and analyzes their possible results after playing 2,000 $109 Online MTTs with an average field of 300 players.

Player	Avg ROI	Buy-ins + Fees	EV	Prob-ability of Loss	Worst Run	Best Run	Worst ROI	Best ROI
A	-25%	$218,000	-$54,500	99%	-$108,755	$6,520	-50%	3%
B	-10%	$218,000	-$21,800	84%	-$81,440	$36,865	-37%	17%
C	0%	$218,000	$0	52%	-$56,630	$88,690	-26%	41%
D	10%	$218,000	$21,800	20%	-$45,035	$95,575	-21%	44%
E	25%	$218,000	$54,500	1%	-$17,330	$131,905	-8%	61%
F	50%	$218,000	$109,000	0%	$35,575	$194,275	16%	89%

Table 30: Simulation of Variation of Results After 2,000 $109 Online MTTs

Even after a sample of 2,000 tournaments it is still possible for Player A, with an average ROI of -25%, to make some profit. Player B, with an ROI of -10%, can have a best run of $36,865, which is more money than Player D's expectation of $21,800, who has an ROI of 10%. Player C is a breakeven player who will lose money ~50% of the time, yet their results can be anywhere from -$56,300 to $88,690. If Player B, with -10% ROI, has their best run, and Player F, with 50% ROI, has their worst run, they both will have very similar results of ~$36k winnings.

If we base our judgment of a player's skill only on the money won, we could mistakenly

assume that Players B and F have the exact same skill or that Player C is a very large winner, when in reality they are just a breakeven player who ran good (this is the reality of many players who have experienced some level of success). The truth is that many players who have won a lot of money are in reality losing players who just ran well. The opposite is also true. There are some great players who simply experienced their worst possible runs over their short sample and were forced to quit the game before being able to turn things around. If we use an even lower sample of 200 games instead of 2,000, this exercise quickly gets out of hand, as shown in *Table 31*.

Player	Avg ROI	Buy-ins + Fees	EV	Prob-ability of Loss	Worst Run	Best Run	Worst ROI	Best ROI
A	-25%	$21,800	-$5,450	82%	-$17,900	$19,270	-82%	88%
B	-10%	$21,800	-$2,180	69%	-$16,460	$20,980	-76%	119%
C	0%	$21,800	$0	52%	-$15,245	$27,760	-70%	127%
D	10%	$21,800	$2,180	44%	-$14,210	$30,040	-65%	138%
E	25%	$21,800	$5,450	28%	-$12,365	$33,820	-57%	155%
F	50%	$21,800	$10,900	10%	-$8,720	$38,575	-40%	177%

Table 31: Simulation of Variation of Results After 200 $109 Online MTTs

In a 200 tournament sample, even a solid winner like Player E, who has a 25% ROI, will lose money 28% of the time, and Player A, with -25% ROI, will sometimes be up $20,000 after playing 200 tournaments.

It is easy to lose perspective and to think irrationally highly of yourself after a few victories. In the hope that it does not happen to you, I am going to share a little story with you.

I learned to play poker in 2009 and started winning small amounts of money in local casinos. In 2010, I final tabled a tournament that brought me $2,000, so I decided to quit my job in a call center and use my $2,000 plus a couple credit cards as a bankroll (probably a lot of you are face-palming yourself right now). Towards the end of 2010, I played one and only one $300 MTT satellite to win a $17,000 package to 2011 PokerStars Caribbean Adventure in the Bahamas, so I was feeling like the king of the world. After just a year of playing, a couple of nice results and reading a few books, I was ready to take the world by storm and crush Ivey, Durrrr and the rest of best players in the world! Or was I?

I ended up bricking the PCA Main Event and busting my entire bankroll during that tournament series, including the credit cards, but at least I got some nice pictures of me

swimming with dolphins plus a photo with my all-time hero Daniel Negreanu.

So, I went broke and, even worse, was now in debt. Somehow, I had $1,000 more available on a credit card, so I grinded my bankroll back up by playing live cash games in the currency of my home country. I could not afford to play the fancy $1/$2 USD games anymore. I had to go back to playing ₡500/₡500, which was roughly $1/$1. So, my bankroll was 10 buy-ins.

I ran hot once again and managed to build a bankroll of $5,000. This allowed me to repay the credit cards and still have a bit left over but then, towards the end of 2011, I again got overly confident and started playing games in USD, "high stakes" $1/$2 and $2/$5 games, despite not having a sufficient bankroll. I somehow convinced myself that I had just been really unlucky and that I was a great player (another face-palm). I am sure you already know that I busted my bankroll yet again. This time, I had to get a job.

After going broke for the second time, I was completely sick of poker, yet I still blamed bad luck. I quit poker for a year but the lure of the game eventually proved too much and I tried my luck in an $11 online rebuy MTT. I managed to win it for $10,000 and then hopped right back into the $1/$2 games. This time though, I won about $6,000 during December 2012, so my delusions got reinforced due to my good luck. I told myself, "I was made to play poker, I just needed to trust myself", so (of course) in January 2013, I quit my nice job as a financial analyst as well as college because I had decided that I was going to focus entirely on poker.

After "going pro", I had a great start and rapidly turned my $16,000 bankroll into $30,000. I felt like this time I had really made it, so I started playing $2/$5 on a regular basis and traveled a few times to other Latin American countries, hoping to win a prestigious Latin American Poker Tour title and change my life for good. What instead happened was I blasted off most of my bankroll.

As a general tip, life does not change when you win a poker tournament or come into money. If you want to change your life, you have to change your habits. Every single day, small actions subtly move your life in either the right or wrong direction. I wish I knew this back then!

At this point in time, I had completely stopped studying the game. I thought I was super-talented and I had already read the best books anyway. I was overconfident and got a new car, moved to a nice apartment and started living a lifestyle that I couldn't afford. Like clockwork, I again made a lot of mistakes, lent a lot of money to a friend, and when I finally started running "bad"/stopped sun-running, the inevitable happened.

In June 2014 I was down to my last $2,000 and had to make a decision. I could either go back to my day job and forget about poker for good, or lose the fancy apartment and move back in with my mother, giving me one last shot to try to get a backer for online tournaments and start from scratch playing micro stakes.

To cut a long story short, I finally understood that I must have been doing something wrong

and that I wasn't anywhere as good as I thought I was, so I owned my mistakes and swallowed my pride. I applied to pocarr.com where I was able to watch numerous training videos and get coaching from top players. I started studying GTO and then I moved up in stakes very quickly. I eventually became a coach and, after many ups and downs, by the end of 2018 I can finally say that I made it. I always dreamt of playing the WSOP Main Event and now I am in the position to go to Las Vegas every year. I play a lot of high buy-in events, including the main event, and play $5/$10 and $10/$20 cash games. I could actually play higher, but I am not looking to blast off my bankroll anymore!

I wanted to share my story because I think that perhaps if I had found a book that explained how poker *actually* works, including concepts such as variance, ROI, EV and win rates, I could have saved myself a lot of trouble. That said, I can't really complain because, despite all my mistakes, I was lucky to get where I am today. And so, while writing my first poker book I can't help but to smile and feel humble and grateful for having the opportunity of doing what I love.

MTT Bankroll Management

The first thing you need to do is figure out how much of your net worth you are willing to use as your bankroll. If you are a professional poker player then your bankroll should be a large percentage of your net worth, and if you are not a professional player your bankroll should be an amount you can afford to lose but still large enough for you to care about it.

Once you know how large your bankroll is, you need to decide which games you can play with it. I generally suggest keeping at least 200 buy-ins in your bankroll. Of course, the more buy-ins you have, the lower the probability of going broke. If you really want to minimize the risk of going broke, 1,000 buy-ins are recommended.

If you plan on becoming a professional, I recommend you have money that is separate from your bankroll to cover your living expenses for at least six months. If you want to avoid stressful monetary situations, you should keep a year's worth of expenses or even more.

As you can tell, these bankroll requirements are quite large compared to what many poker players actually have, unless they get lucky to win a huge tournament early in their career. For this reason, backing deals are a great opportunity to start playing higher than you otherwise could yourself. Many backers offer deals where the player keeps half of the wins with makeup, meaning losses accumulate and have to be paid off before the profit is split. For example, if you get down $5,000 but then win a tournament for $10,000, $5,000 would cover the makeup and the other $5,000 would be split, giving you $2,500 and the backer $2,500. If you won the first tournament you played for $10,000, there would be no makeup, so you and the backer would

each get $5,000.

Depending on your skill level, you may be able to negotiate a better deal, perhaps 55/45 or even 60/40 in your favor. Some backers offer backing for live tournaments that are 40/60, but the backer covers all traveling expenses.

Finally, if you play live tournaments, you can keep a smaller bankroll because you will have a higher ROI and there are usually fewer players in live tournaments compared to online. This will result in you having smaller swings. Just be sure to account for travel expenses. If you are not diligent, they can quickly pile up, making even large winners into losers.

Game Selection

The topic of game selection has already been discussed when analysing win rates for cash game players. Similar to cash games, in tournaments you need to consider your edge in each event you could play. Of course, if you are the best player in the world and have an infinite bankroll you simply want to play the highest stake games you can find. However, for us mere humans, quite often playing smaller games where our ROI and variance will be lower is a better idea than playing bigger games with higher variance and lower ROI.

A major issue for tournament game selection is that there are only so many tournaments available with a specific buy-in, so you have to choose a range of buy-ins. You then average your buy-ins to determine your average buy-in (ABI) and consider it for bankroll management.

For example, if you play three tournaments with buy-ins of $100, $200 and $500, then your ABI is $267. Playing a very wide spread of buy-ins presents an additional problem. As the spread becomes wider, you will experience more variance.

Table 32 shows the effects that having a wide spread in buy-ins can produce in a player's results. In simulation #1, the player plays a schedule of 1,800 $109 MTTs, 149 $1,050 buy-in MTTs, 49 $2,100 MTTs, one $5,200 MTT, and one $10,300 MTT for a total of 2,000 games. In simulation #2 the player also plays a total of 2,000 games, but instead all buy-ins are exactly $235.

Simu-lation	ROI	Buy-ins + Fees	Ev	Prob-ability of Loss	Worst Run	Best Run	Worst ROI	Best ROI
#1	25%	$471,050	$117,763	30%	-$262,450	$1,441,550	-56%	306%
#2	25%	$468,000	$117,000	3%	-$36,127	$374,486	-8%	80%

Table 32: Variation of Results with a Wide Spread in Buy-ins

In both situations the player invests approximately the same amount of money and has the same EV, but the probability of loss is 10x larger in Situation #1 when they play the schedule with a wide spread in buy-ins and can experience swings from -$262,000 to $1.4 million, while their worst possible run in situation #2 is only -$36,000. I learned this the hard way in 2016 when I had my worst downswing ever. I won approximately $60,000 over the course of 2,000 mid-stakes online MTTs, but lost $120,000 playing fewer than 200 high stakes MTTs, including the $10,000 SCOOP High ME and the $5,000 WCOOP ME when my ABI was $103. Losing just those two tournaments cost me 150 buy-ins! (Ouch!)

Table 33 displays actual results for real online players and their respective stats so you can see the correlation between the results and the different metrics. The data is taken from sharkscope.com.

Player	Ability	Total MTTs	ITM	Avg Stake	Avg ROI	Total Stake	Total Cashes	Profit	Total ROI	Early Fin-ishes	Late Fin-ishes
1	99	21,051	15%	$260.00	50%	$5,469,815	$8,654,545	$2,598,215	47%	7%	12%
2	99	17,377	16%	$218.00	38%	$3,787,701	$5,092,441	$918,588	24%	11%	10%
3	98	44,302	15%	$169.00	35%	$7,428,932	$10,367,744	$2,241,117	30%	8%	11%
4	97	22,359	18%	$162.00	37%	$3,624,746	$4,458,181	$333,654	9%	6%	13%
5	97	41,574	17%	$138.00	36%	$5,736,861	$7,374,637	$1,070,585	18%	8%	12%
Avg	98	29,333	16%	$189.40	39%	$5,209,611	$7,189,510	$1,432,432	26%	8%	11%

Table 33: MTT Results of Some of the World's Best Players

Ability is a rating developed by SharkScope. It goes up to 100 and shows a player's ability based on an assessment of all the other statistics. *Early Finishes* refers to the frequency a player has finished in the bottom 10% of tournaments, and *Late Finishes* refers to the frequency a player has finished in the top 10%.

Player 1 is arguably the best online MTT player in the world. After 21,000 MTTs played, he crushed the highest stakes with a 50% Avg ROI, for an astonishing net profit of $2.6 Million!

Players 2, 3, 4 and 5 crush the high stakes and are also among the best players in the world.

Player	Ability	Total MTTs	ITM	Avg Stake	Avg ROI	Total Stake	Total Cashes	Profit	Total ROI	Early Fin-ishes	Late Fin-ishes
6	95	17768	19%	$53.87	40%	$957,224	$1,806,155	$761,898	75%	10%	12%
7	93	25279	20%	$42.94	40%	$1,085,444	$1,398,509	$221,066	19%	7%	13%
8	92	31443	19%	$33.19	55%	$1,043,654	$2,088,651	$952,746	85%	7%	12%
9	91	25169	23%	$33.22	38%	$836,040	$1,356,690	$446,175	50%	10%	11%
10	89	21302	22%	$33.13	48%	$705,769	$1,103,879	$338,154	44%	7%	13%
Avg	92	24192	21%	$39.27	44%	$925,626	$1,550,777	$544,008	55%	8%	12%

Table 34: MTT Results of Great Players in the Mid-high Stakes

Players 6-10 are great players who play the mid-high stakes *(Table 34)*. This type of player has the potential to become one of the best players in the world. Some of them are still working towards that goal while others are content with just printing money at the mid-stakes.

Player	Ability	Total MTTs	ITM	Avg Stake	Avg ROI	Total Stake	Total Cashes	Profit	Total ROI	Early Fin-ishes	Late Fin-ishes
11	87	5188	23%	$102.00	24%	$530,408	$583,434	$2,420	0%	7%	12%
12	80	21248	24%	$13.46	34%	$285,896	$372,247	$61,350	20%	8%	12%
13	78	13916	23%	$10.54	32%	$146,631	$191,728	$32,887	21%	7%	13%
14	76	4230	18%	$46.62	21%	$197,187	$159,647	-$54,078	-26%	12%	10%
15	75	8645	27%	$5.80	62%	$50,156	$71,808	$16,214	30%	3%	13%
Avg	79	10645	23%	$35.68	34%	$242,056	$275,773	$11,759	9%	7%	12%

Table 35: MTT Results of Low- and Mid-stakes Regulars

Players 11-15 are low and mid stakes regulars *(Table 35)*. In this group we start to see lower Avg ROIs and also a wider spread in their results, with some of them winning small amounts or even losing. These type of players should spend more time working on their game, making sure they have all the fundamentals well covered. They should actively be looking for a poker mentor/coach, or join a group of players who study together and support each other.

Players 11 and 14 are clearly playing too high for their current skill level.

Player	Ability	Total MTTs	ITM	Avg Stake	Avg ROI	Total Stake	Total Cashes	Profit	Total ROI	Early Fin-ishes	Late Fin-ishes
16	73	33244	24%	$42.49	10%	$1,412,598	$1,440,262	-$90,179	-6%	11%	12%
17	73	6062	13%	$215.00	-33%	$1,302,614	$1,102,546	-$330,395	-25%	16%	7%
18	72	6097	14%	$173.00	-25%	$1,056,555	$605,364	-$546,262	-50%	15%	7%
19	70	3415	31%	$74.61	-22%	$254,788	$212,976	-$64,035	-23%	9%	12%
20	69	7972	12%	$68.12	-37%	$543,015	$350,413	-$239,314	-42%	15%	6%
Avg	71	11358	19%	$114.64	-21%	$913,914	$742,312	-$254,037	-29%	13%	9%

Table 36: MTT Results of Losing Players

Players 16-20 are losing players *(Table 36)*. All of them are playing stakes too high for their current skill level. They should stop playing the higher buy-in games, put a lot of work in on their technical abilities, read theory books, watch as many instructional videos as they can and definitely get professional coaching to help them fix their biggest leaks. In general, they seem to be busting the tournaments a little too often in the early stages and not getting to the late stages as often as they should.

The Mental Game

There are several books written about the mental game, such as *Positive Poker* and *Peak Poker Performance* both by Dr. Patricia Cardner and Jonathan Little, so I won't be spending a lot of time in this section of the book.

> *However, it is worth mentioning that mental game is absolutely key in poker success and particularly in MTTs.*

Mental game has been my biggest leak during most of my poker career and there are some aspects of it that I still occasionally struggle with. Thanks to my mental game coaches Elliot Roe and Dr. Tricia Cardner, I was able to overcome most of my mental game limitations, so I strongly recommend you to read books on mental game, listen to podcasts, watch videos and, if possible, get coaching if you really want to succeed at poker.

In my experience, there are several mindset traits that winning players have in common, while losing players tend to be on the opposite side of the spectrum. They can be summarised as

follows:

Winning Player

- ♦ Generally positive attitude.
- ♦ Understands variance but takes full responsibility for their results.
- ♦ Great work ethic, constantly works on improving their game and puts in the volume.
- ♦ Has emotions under control.
- ♦ Is always looking for feedback and open to criticism.
- ♦ Long-term results oriented.
- ♦ Increases EV by playing weaker opposition most of the time.
- ♦ Plays only as many tables as possible while remaining mindful and playing their A+ game.
- ♦ Takes care of their health by eating healthy foods, working out, meditating and drinking a lot of water.
- ♦ Sleeps well, particularly the nights before big events.
- ♦ Pre- and post-game routines.
- ♦ Is part of a network of likeminded successful poker players and constantly discusses poker hands and strategy with them.

Losing Player

- ♦ Generally negative attitude.
- ♦ Blames variance, bad luck, the poker room or even the dealers for their bad results.
- ♦ Is lazy, never works on their game and struggles to put in the hours at the tables.

♦ Is often on tilt.

♦ Doesn’t take criticism.

♦ Short-term results oriented.

♦ Has a huge ego, therefore plays against better opponents all the time.

♦ Plays too many tables and autopilots, generally playing their B or C game.

♦ Doesn’t take care of their health, eats junk food and never works out.

♦ Drugs/alcohol abuse.

♦ Doesn’t have good sleeping habits, has no problem with going out and partying the night before a big event.

♦ Jumps directly from bed to the poker tables.

♦ Tells bad beat stories and complains about how unlucky they are to poker friends.

Tournament Life

I mentioned earlier how MTTs are fundamentally different to cash games and also how top MTT players have a good grasp on how to adjust to the different stages of a tournament. This is because they understand the concept of tournament life.

Winning a Poker Tournament

Winning a tournament can be seen in two different ways. We all know that the winner of a tournament is the player who wins all the chips, but another way to see it is that the winner of a tournament is the last player standing.

Tournaments are about survival, outlasting your opponents rather than trying to bust them yourself. So, tournament life refers to the value of still having chips in a poker tournament.

If tournaments are not driven solely by Chip EV (cEV), what other factors should impact your decisions at the table?

The EV of Future Hands

This concept is easier to understand with an example.

Example

You are playing the WSOP ME and on the first hand of the first level with 50,000 chips at 75/150 (333bb deep) it is folded to the SB, a crazy guy, who goes all-in without looking at his cards. You are in the BB and look down to J8o. Would you call?

J8o is ahead of a random hand, having 51.48% equity. Calling makes 10.9bb per hand, so is worth 1,090bb/100. Analyzing the spot from a cEV perspective, it should be an easy call because folding is 0bb EV. However, it should be obvious to most people that you cannot call off with J8o in this spot even if it is a +cEV play, but why is that?

If you wait for a premium hand such as AA next time the crazy dude shoves, you will make +235bb per hand or 23,500bb/100. So, there is a lot of value in waiting for better spots. While this is clearly an extreme example and you have to figure out how often a better spot will come up, it serves the purpose of illustrating the EV of future hands.

The EV of Gaining a Higher Payout

This concept is straightforward. Avoiding losing all your chips in a tournament has the potential to gain you a higher payout because other players may get eliminated before you. So, there is value in folding and staying alive, hoping for other players to bust. This is quite different from cash games where the EV of folding is always 0.

The main issue with these factors is that they are not easy to quantify. This is why mathematical models (algorithms) such as the Independent Chip Model (ICM) and Future Game Simulation (FGS) were developed.

The Independent Chip Model (ICM)

In a cash game if you double your starting stack, you double your money, but in a tournament, the number of chips and their monetary value are not directly correlated. Let’s see an example.

Example

You are playing a 10-person $10 buy-in SNG with a total prize pool of $100. Only the top three players will be paid, with first getting $50, second $30 and third $20. For simplicity, there is no rake.

At the beginning of the SNG, each player is given 1,000 chips and they are worth $10. If you bust before getting into the money, you lose $10, and if you win the tournament, you end up with

10,000 chips. The total prize pool was $100 yet you only get paid $50. So, you ended with 100% of the chips but are paid only 50% of the prize pool.

Multiplying your stack does not multiply its value, so even if you double up on the first hand of an SNG and end up with a stack of 2,000 chips, the value of your stack does not double. The chips you won are worth less than the chips you risked.

> *This is known as the Principle of Diminishing Chip Value: In poker tournaments, the chips risked are worth more than the chips won, and the more chips you have, the less each chip is worth.*

ICM is a mathematical model designed to assign a monetary value to chip stacks that is representative of their equity share of the remaining prize pool.

Based on the stack sizes, ICM calculates the probability of each player finishing in a particular place and multiplies those probabilities by the payouts for each position. These calculations are generally too complicated to perform by hand, but fortunately there are many online ICM calculators such as holdemresources.net/icmcalculator that can be used for free.

Returning to our 10-person SNG example, imagine there are four players remaining with the following stack distributions *(Table 37)*.

Player	Stack	Chip%	ICM$
A	6,000	60%	$40.39
B	1,800	18%	$24.53
C	1,200	12%	$18.85
D	1,000	10%	$16.24

Table 37: Example of an ICM Outcome

Player A has 60% of the chips, but their stack value isn't $60 as the most they can possibly win is $50 by finishing first. Since they will not finish first 100% of the time, their stack value has to be less than $50. ICM assigns a value of $40.39 to his stack.

Player D is the short stack and has 10% of the chips in play, but this stack is worth a lot more than $10.

ICM is widely used for final table deal making, although it tends to overvalue short stacks. Another model used for deal making is Chip Chop, but Chip Chop tends to overvalue big stacks. Using Chip Chop in our example, Player A, who has 60% of all the chips, would get a payment of $60, which is more than first place. Clearly that is irrational.

The discrepancy between chip values and monetary value generates two types of EV for

players' actions:

♦ **Chip Expected Value (cEV):** The average number of chips you can expect as the result of an action.

♦ **Monetary Expected Value ($EV):** The average amount of money you can expect as the result of an action, based on your current prize pool equity.

In cash games, cEV and $EV are the same (ignoring rake); however, in MTTs, the player's decisions should always be based on $EV.

Let's see a practical example using Holdem Resources Calculator (HRC) to calculate cEV and ICM push/fold equilibrium strategies with 50/100 blinds.

Player	Stack	cEV Push Range	ICM Push Range
CO	1,000	26.20%	14.20%
BN	1,200	32.10%	15.70%
SB	1,800	42.40%	14.90%
BB	6,000	-	-

Table 38: ICM Dictates Tight Pushing

In *Table 38* we can see how the CO, BN and SB are forced to play really tightly because of the money bubble. Many hands that are profitable cEV shoves are -$EV shoves, so they can no longer be pushed.

Player	Stack	cEV Push Range	ICM Push Range
CO	1,000	26.50%	14%
BN	6,000	27.40%	100%
SB	1,800	53.20%	100%
BB	1,200	-	-

Table 39: ICM Dictates Wide Pushing

In *Table 39* the BB and the BN stacks have been switched and now the BN can take advantage of his big stack and push any two cards as the blinds are forced to call off really tightly due to ICM.

The effect of ICM in equilibrium strategies depends on the stack sizes and the tournament payment structure. Tournaments that are very top-heavy reward more aggressive play and tournaments with a flatter structure reward tighter play.

It is also important that you pay close attention to your opponents' strategies, as you can't apply ICM pressure to players who are not ICM aware or players who choose not to follow ICM. The push/fold calculator assumes all players play ICM equilibrium strategies. If there is a player who doesn't follow ICM and you get involved in a hand against them, they can cost you EV, and that EV will be transferred to the other players at the table.

For example, in *Table 38*, the SB ICM strategy is to push 14.9% of hands, but that assumes the BB is ICM aware and thus calls with only 6.7% of hands. If the BB is calling a regular cEV range of 23.8% hands, both blinds would lose EV even though you are playing "correctly".

ICM and Solvers

Before modern solvers existed, ICM calculations were only possible for simple push/fold situations, but most solvers have now incorporated ICM calculators, opening a new world of possibilities for the development of final table strategies. With so many different final table payment structures and possible stack depth distributions, it's almost impossible to develop full strategies to cover all possibilities and, anyway, that would go way beyond the scope of this book. Instead, we are going to be focusing on the study of regular equilibrium strategies, but I do recommend you run your own ICM calculations and develop a sense for how to deviate from "standard" play in final table and bubble situations.

ICM Limitations

ICM is based on some specific assumptions that make the calculations possible:

- ♦ Calculations are performed for the current hand in a vacuum, and any future play is ignored, such as blinds increasing on future hands, or the future value of building a big stack and gaining the ability to push shorter stacks around.
- ♦ ICM assumes all players are of equal skill.
- ♦ Players' table image is irrelevant.
- ♦ Calculations are limited to a fixed number of players, usually down to the final table only, or final two tables, so ICM can't be applied to the earlier stages where players are still far

away from the money.

♦ ICM does not consider the players' positions. For example, a 4bb stack on the BN is far more valuable than in first position.

Because of these assumptions, ICM isn't perfect. However, it still provides excellent $EV approximations that help players make better decisions during final tables, money bubbles and SNGs.

ICM General Guidelines

Obviously, it is almost impossible to run ICM calculations during actual play, but analyzing different ICM setups in your study time can greatly help you develop the right instincts. Next, we summarize some of the most useful ICM guidelines:

♦ Call off tighter in tournaments than in cash games.

♦ Avoid marginal +cEV spots.

♦ Medium stacks are forced to play tightly in the presence of short stacks, and particularly during the money bubble.

♦ Big stacks can threaten medium size stacks, particularly during the money bubble as they can only stack off with very tight ranges.

Risk Premium

In tournaments, because of the principle of diminishing chip value, we know that the chips you can win aren't necessarily worth as much as the chips you already have. You can think about it as risking more for a pot that is in practice smaller than cEV suggests. Therefore, in tournaments, you need more equity than in cash games to make a +$EV play. This extra equity is what we call risk premium *(Diagram 17)*.

Diagram 17: Risk Premium

Returning to our 10-person SNG example, as we saw in *Table 39*, the BN who is the chip leader with 6,000 chips can go all-in with any two cards. I mentioned that according to ICM, the blinds are forced to call with very tight ranges because of the money bubble. In fact, after the BN goes all-in with 100% hands the SB, who is the second stack with 1,800 chips, has a calling range of only AA-TT. If the SB folds, then the BB has a calling range of only AA-88, AKs, and AQs.

Let's calculate the cEV of the BB's call with AKo against the BN's all-in, assuming the SB has already folded, based on the equities in *Table 40*.

Hand	Equity Versus 100% Range
AA	85.20%
KK	82.40%
QQ	79.92%
JJ	77.47%
TT	75.01%
99	72.06%
88	69.16%
AKs	67.04%
AKo	65.32%

Table 40: Equities Versus a 100% Range

$$BB\ cEv\ [Call\ AKo] = [\%\ W * Chips\ W] - [\%L\ * Chips\ R]$$

$$BB\ cEv\ [Call\ AKo] = [65.32\% * 1{,}350] - [34.68\% * 1{,}100]$$

$$BB\ cEv\ [Call\ AKo] = [881.82] - [381.48]$$

$$BB\ cEv[Call\ AKo] = 500$$

Calling off with AKo is clearly very profitable in terms of chips, so now let's calculate the $EV of the BB's call with AKo in the same spot:

$$BB\ \$Ev\ [Call\ AKo] = [\%W * \$W] - [\%L * \$R]$$

Using HRC ICM calculator, the current value of BB's stack after a fold is $18.02. Instead, after a call and a win, the value of this stack with the new stack distributions would be $27.12, so the $ value added to BB's stack is:

$$\$W = \$27.12 - \$18.02 = \$9.1$$

Then:

$$BB\ \$Ev\ [Call\ AKo] = [65.32\% * \$9.1] - [34.68\% * \$18.02]$$

$$BB\ \$Ev\ [Call\ AKo] = [\$5.94] - [\$6.25]$$

$$BB\ \$Ev\ [Call\ AKo] = -\$0.31$$

So, calling off with AKo is unprofitable in terms of monetary value.

Using the EV equations, we can calculate the minimum equity required to make this call profitable:

$$[EQ * Chips\ W] - [1 - EQ * Chips\ R] > 0$$

$$[EQ * 1{,}250c] - [1 - EQ * 1{,}100c] > 0$$

$$[1{,}250\ cEQ] - [1{,}100c - 1{,}100cEQ] > 0$$

$$[1{,}250\ cEQ] + 1{,}100\ cEQ > 1100c$$

$$2{,}350\ cEQ > 1{,}100c$$

$$EQ > \frac{1{,}100c}{2{,}350c}$$

$$EQ > 47\%$$

Now let's do the same with the $EV equation:

$$[EQ * \$9.1] - [1 - EQ * \$18.02] > 0$$

$$[\$9.1\ EQ] - [\$18.02 - \$18.02\ EQ] > 0$$

$$[\$9.1\ EQ] + \$18.02\ EQ > \$18.02$$

$$\$27.12\ EQ > \$18.02$$

$$EQ > \frac{\$18.02}{\$27.12}$$

$$EQ > 66.44\%$$

For the BB to have a + $EV call with their hand, they need to have 66.44% equity, while for the call to be +cEV, they can call any hand with 47% equity. The difference in equity is the risk premium:

$$Risk\ Premium\ [BB\ vs\ BN] = 66.44\% - 47\%$$

$$Risk\ Premium\ [BB\ vs\ BN] = 19.44\%$$

Risk Premium Correlation Matrix

Risk premium changes depending on the stack sizes of players involved in the hand and is higher when calling big bets, particularly if calling for all your chips and putting your tournament life at risk *(Table 41)*.

Versus	Big Stack	Mid Stack	Short Stack
Big Stack	18%-25%	6%-8%	2%-4%
Mid Stack	13%-15%	10%-12%	5%-7%
Short Stack	9%-12%	8%-10%	7%-10%

Table 41: Average MTT Risk Premium Values

Depending on the tournament pay structure and exact stack distribution, risk premium might vary. The flatter the payment structure, the higher the risk premium and the more top heavy the payment structure, the less risk premium. In winner-takes-all tournaments, there is a risk premium of 0 because there is no benefit in moving up the payout ladder. The presence of very short stacks will increase the other players' risk premiums (particularly other short stacks).

For calling small bets such as min-raises, risk premium can be less than 2% but it still makes a difference in BB defending ranges, particularly for the bottom of a range that is made of hands that are marginally +cEV calls. Another reason to defend tighter from the BB when you have a high risk premium against the opener is that risk premium also applies to post-flop bets. It will be quite difficult for the BB to call bets across multiple streets and so their EQR will be even lower than in a regular cEV spot. Notice that risk premium is the extra equity required for a play to be profitable. This means that it does not only apply to calling bets, but also to making them. For this reason, the BB should defend wider against players who have a high risk premium against them as they will struggle to barrel off and the BB will be able to realize more equity than in a regular cEV spot.

Future Game Simulation (FGS)

As mentioned previously, ICM is not perfect and so newer models such as FGS were developed specifically to target some of ICM limitations such as:

- ♦ The players' positions relative to the blinds.
- ♦ The size of the blinds and antes relative to the stacks.
- ♦ The fact that the blinds move around the table.

FGS runs ICM simulations involving a number of hands subsequent to the current one, calculating the probability of each possible outcome and the ICM EV of each player's stack for

each outcome.

Some situations where players can benefit from using FGS over ICM are when:

- ♦ The blinds are about to increase.
- ♦ Players are very short stacked and afraid of losing playability or fold equity.
- ♦ There is a high chance of a short stack busting soon or blinding out (this is particularly useful during money bubbles or when playing satellites).

While FGS is an improvement on ICM and generates a closer approximation to real $EV by looking into the future, the model still has its own limitations:

- ♦ FGS calculations are a lot more resource-intensive than regular ICM, and therefore they take a lot more time to be computed.
- ♦ FGS ignores post-flop play and can only be used for push/fold calculations for a limited number of players, and is therefore useless for the early stages of an MTT.
- ♦ FGS based results are significantly different from ICM only in situations where the table is relatively short-handed (six players or fewer), and stacks are shorter than 10bb, with some extremely shallow stacks (5bb or fewer).

The most affected positions will be UTG, SB and BB.

The most important concept that can be derived from these models is the principle of diminishing chip value: In poker tournaments, the chips risked are worth more than the chips won, and the more chips you have, the less each chip is worth.

Until now the mathematical models we have used to assign a monetary value to chip stacks, ICM and FGS, are both limited to situations where players are already in the money, or very close to it, but what happens in the earlier stages of a tournament? Is the principle of diminishing chip value still applicable? Should players be risk prone or risk adverse? What about other factors that aren't covered by the models, such as skill edge?

The Gambler's Ruin Problem

Consider a situation where two players begin with fixed stakes, transferring points until one or

the other is “ruined” by reaching zero points.

Gamblers who are playing a fair game (with 50% probability of winning) will eventually either go broke or double their wealth. These events are equally likely or the game would not be fair.

Fair Coin Flipping

Consider a coin-flipping game with two players where each player has a 50% chance of winning each flip of the coin. After each flip of the coin the loser transfers one chip to the winner. The game ends when one player has all the chips.

If Player1 has n1 chips and Player2 n2 chips, the probabilities that Player1 (P1) and Player2 (P2) will lose all their chips are:

$$P_1 = \frac{n_2}{n_1 + n_2}$$

$$P_2 = \frac{n_1}{n_1 + n_2}$$

Consider when both players have the same number of chips. Let’s suppose both players have six chips. The likelihood of each player losing is:

$$P_1 = \frac{6}{6+6} = \frac{6}{12} = \frac{6}{12} = 0.5$$

$$P_2 = \frac{6}{6+6} = \frac{6}{12} = \frac{6}{12} = 0.5$$

Now let’s suppose one player has more chips than the other. Let’s give P1 8 chips and P2 only 5 chips. Then the probability of each losing is:

$$P_1 = \frac{5}{8+5} = \frac{5}{13} = 0.3846 = 38.46\%$$

$$P_2 = \frac{8}{8+5} = \frac{8}{13} = 0.6154 = 61.54\%$$

We conclude (unsurprisingly) that even with equal odds of winning, the player who starts with fewer chips is more likely to lose.

Unfair Coin Flipping

In the event of an unfair coin, where P1 wins each toss with probability p, and P2 wins with probability q = 1-p, then the probability of each player going broke is:

$$P_1 = \frac{1 - \left(\frac{p}{q}\right)^{n_2}}{1 - \left(\frac{p}{q}\right)^{n_1 + n_2}}$$

$$P_2 = \frac{1 - \left(\frac{q}{p}\right)^{n_1}}{1 - \left(\frac{q}{p}\right)^{n_1 + n_2}}$$

Let's focus our attention in P2's probability of losing, which is exactly the same as the probability of P1 winning:

$$P_1[Win] = P_2 = \frac{1 - \left(\frac{q}{p}\right)^{n_1}}{1 - \left(\frac{q}{p}\right)^{n_1 + n_2}}$$

Consider a gambling game where there are 20 total chips in play. Hero is P1, what is Hero's probability of winning with different stack sizes when:

♦ The game is fair (both players are equally likely to win)

♦ Hero has a skill edge (52% probability of winning each individual gamble)

♦ Hero has a skill deficit (48% probability of winning each individual gamble)

Starting Stack	Fair Game		Skill Edge		Skill Deficit	
	Win%	Slope	Win%	Slope	Win%	Slope
0	0%	0.05	0%	0.096	0%	0.021
1	5%	0.05	10%	0.089	2%	0.023
2	10%	0.05	19%	0.082	4%	0.025
3	15%	0.05	27%	0.076	7%	0.027
4	20%	0.05	34%	0.070	10%	0.029
5	25%	0.05	41%	0.065	12%	0.031
6	30%	0.05	48%	0.060	16%	0.034
7	35%	0.05	54%	0.055	19%	0.037
8	40%	0.05	59%	0.051	23%	0.040
9	45%	0.05	64%	0.047	27%	0.043
10	50%	0.05	69%	0.043	31%	0.047
11	55%	0.05	73%	0.040	36%	0.051
12	60%	0.05	77%	0.037	41%	0.055
13	65%	0.05	81%	0.034	46%	0.060
14	70%	0.05	84%	0.031	52%	0.065
15	75%	0.05	88%	0.029	59%	0.070
16	80%	0.05	90%	0.027	66%	0.076
17	85%	0.05	93%	0.025	73%	0.082
18	90%	0.05	96%	0.023	81%	0.089
19	95%	0.05	98%	0.021	90%	0.096
20	100%		100%		100%	

Table 42: Probabilities of Winning Coin Flipping Game

With identical skill levels, Hero's probability of winning increases linearly with their chip stack. If Hero has 2 chips, the probability of winning is 10%, if they double their stack to 4 chips, the probability of winning doubles to 20%. If they have 10 chips (half the chips in play) the probability of winning is 50%.

When Hero has a skill edge, their probability of winning no longer increases linearly with the chip stack. If Hero has 2 chips the probability of winning is 19% and if they double their stack to 4 chips, the probability of winning increases to 34% (it does not double). If they have 10 chips

(half the chips in play) their probability of winning is 69%. This is because the value function isn't a straight line but instead has a concave shape. So, the more chips Hero has, the less steep the line becomes, and the lower the marginal value of each new chip added to the stack *(Diagrams 18 and 19)*.

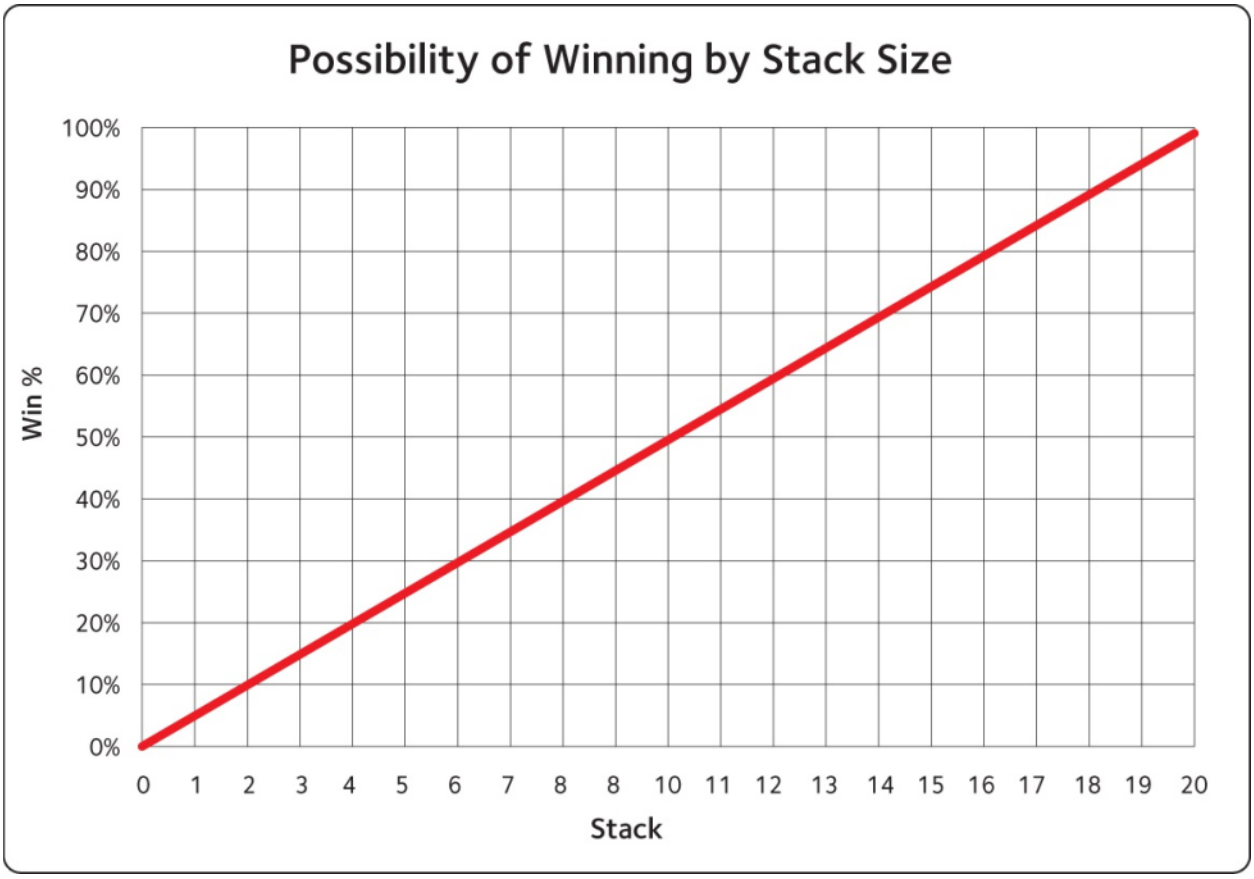


Diagram 18: Fair Game (p=0.5)

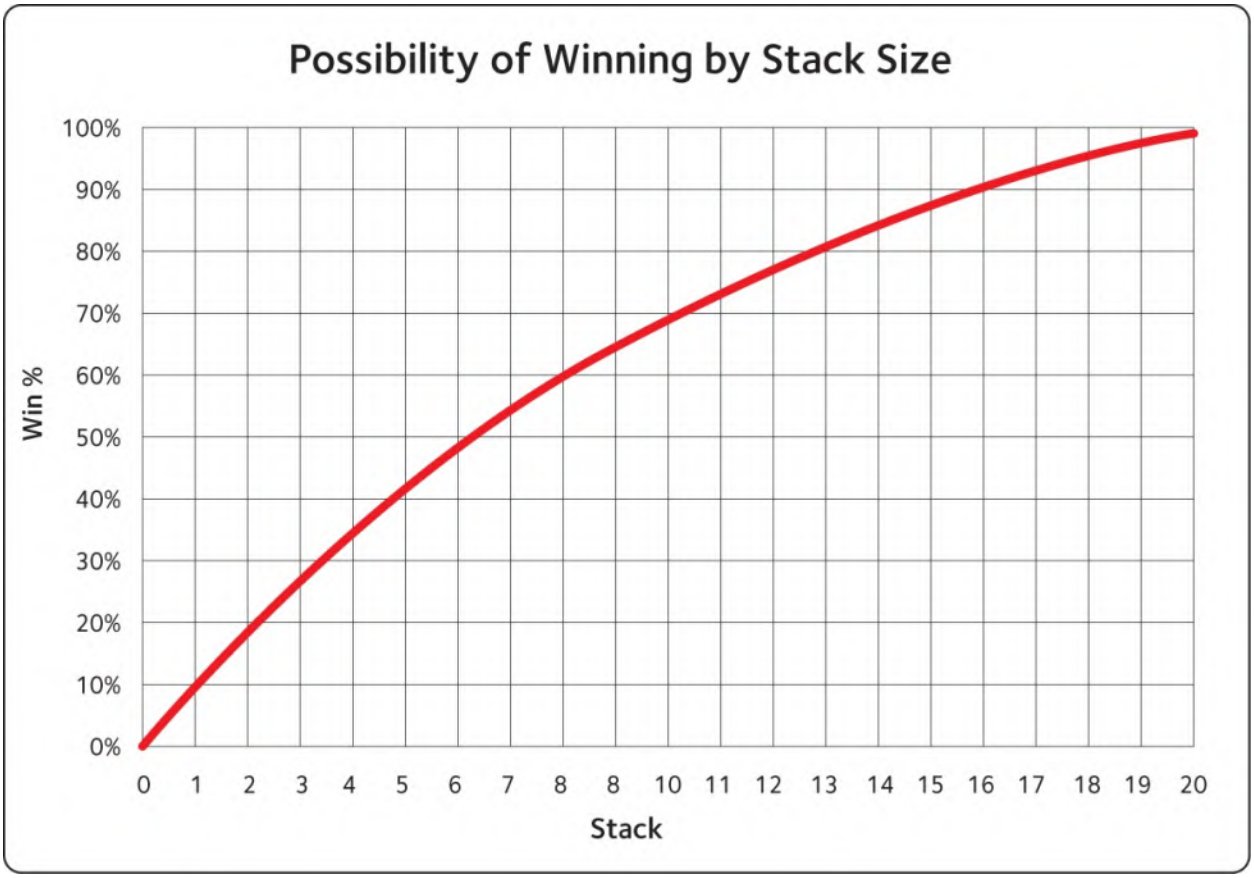


Diagram 19: Skill Edge (p=0.52)

As Hero's stack size increases, the slope at the point of the curve decreases. For example, the curve is steeper at 2 than at 18. The line's slope is the marginal value of each chip Hero adds to their stack. With identical skill edge, the marginal value of each chip added is 0.05, but in the case of skill edge or skill deficit, the value function isn't a straight line and thus the marginal value of chips added will vary depending on the total chips Hero already has. The last chip added to Hero's stack when they have the skill edge is the least valuable (0.021). The last chip added to Hero's stack when they have the skill deficit is the most valuable one (0.096).

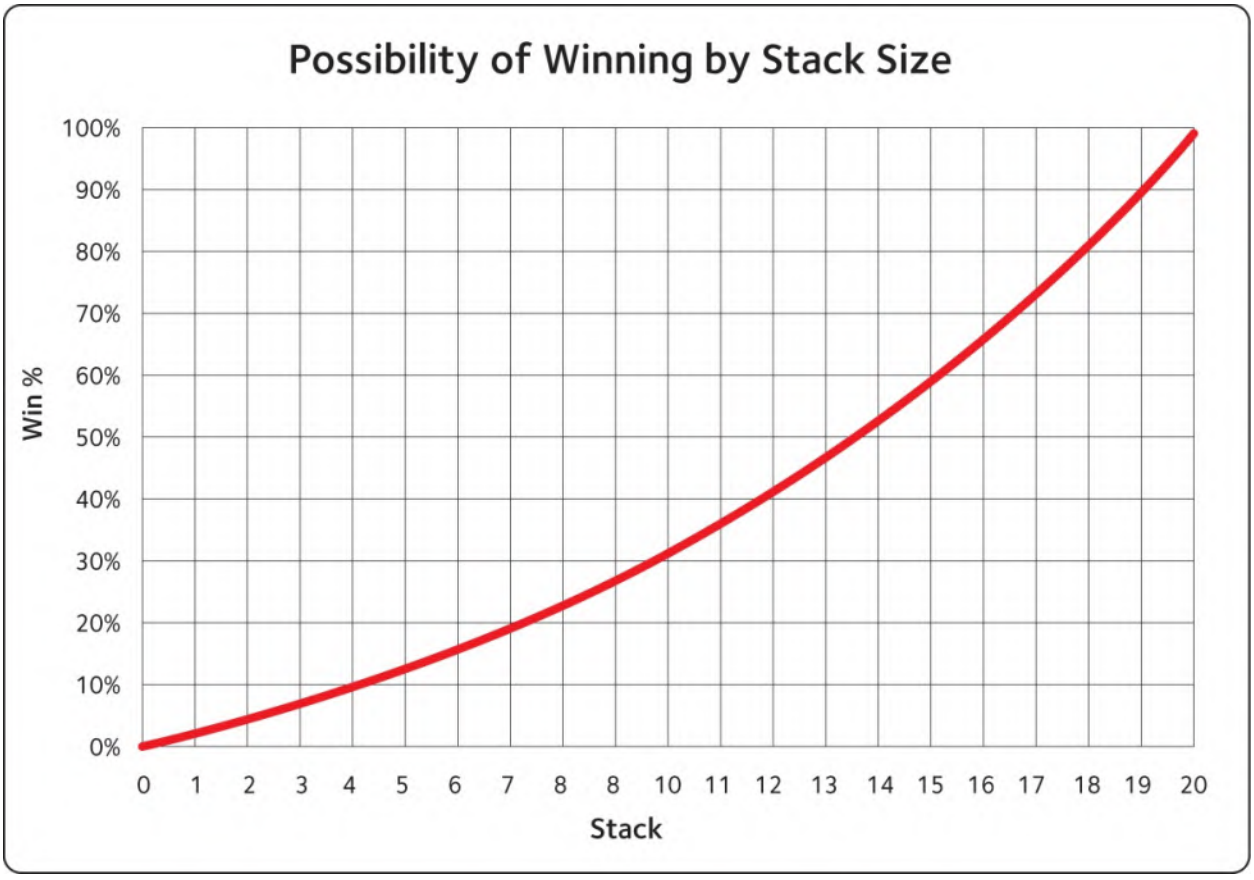


Diagram 20: Skill Deficit (p=0.48)

When Hero has a skill deficit *(Diagram 20)*, their probability of winning also does not increase in a linear fashion with the chip stack. If Hero has 2 chips their probability of winning is 4%, if they double their stack to 4 chips, the probability of winning is 10% (more than double). If they have 10 chips (half the chips in play) their probability of winning is *only* 31%.

For example, imagine Hero is offered a coin flip to play for 5 chips when stacks are 10 chips. The EV they get from that gamble can be calculated by drawing a straight line from 5 to 15 and taking the value that is half of it. If Hero has a skill edge, that value will always be below the curve, meaning that any even gamble in cEV will be -EV in probability of winning. If they have a skill deficit the value will always be above the curve and any 0 cEV gamble will be +EV in terms of probability of winning.

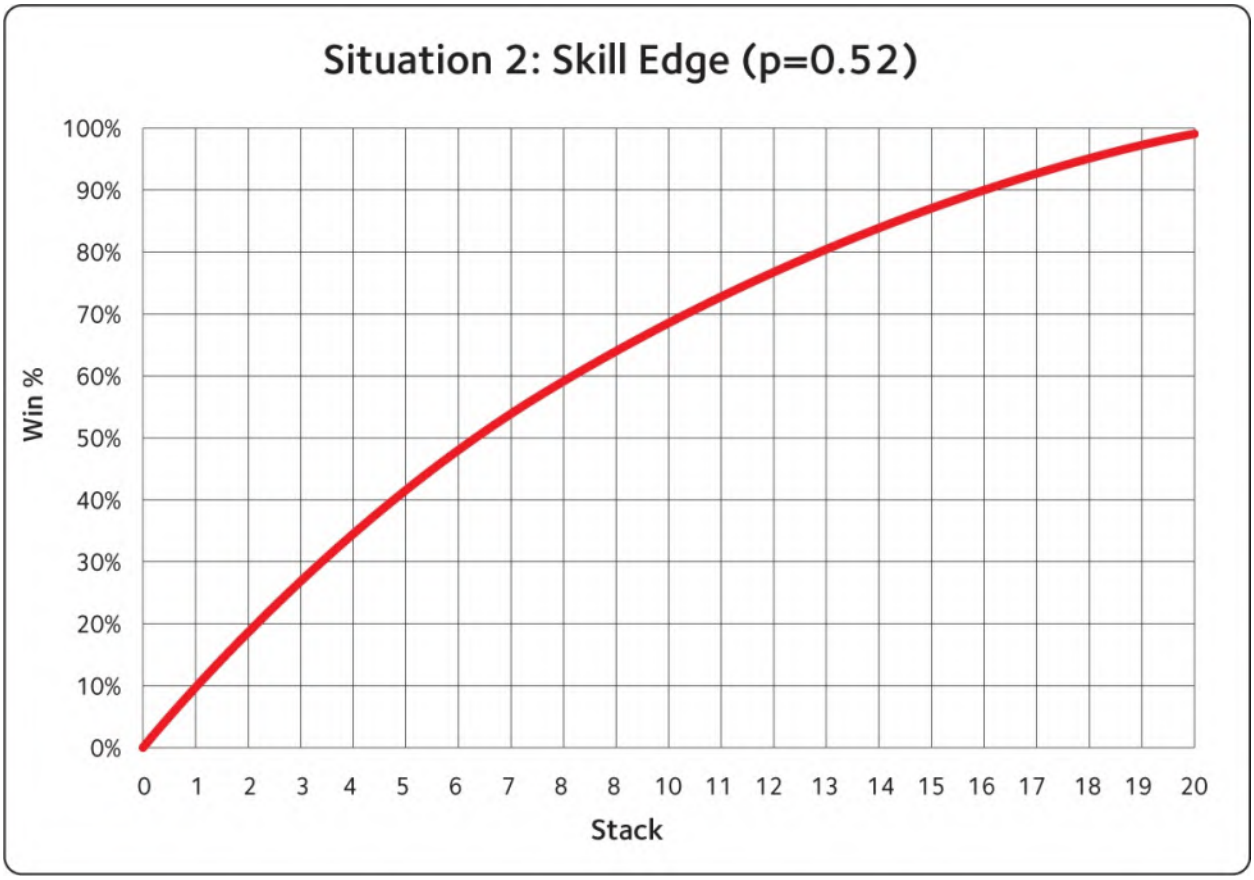


Diagram 21: Skill Edge (p=0.52)

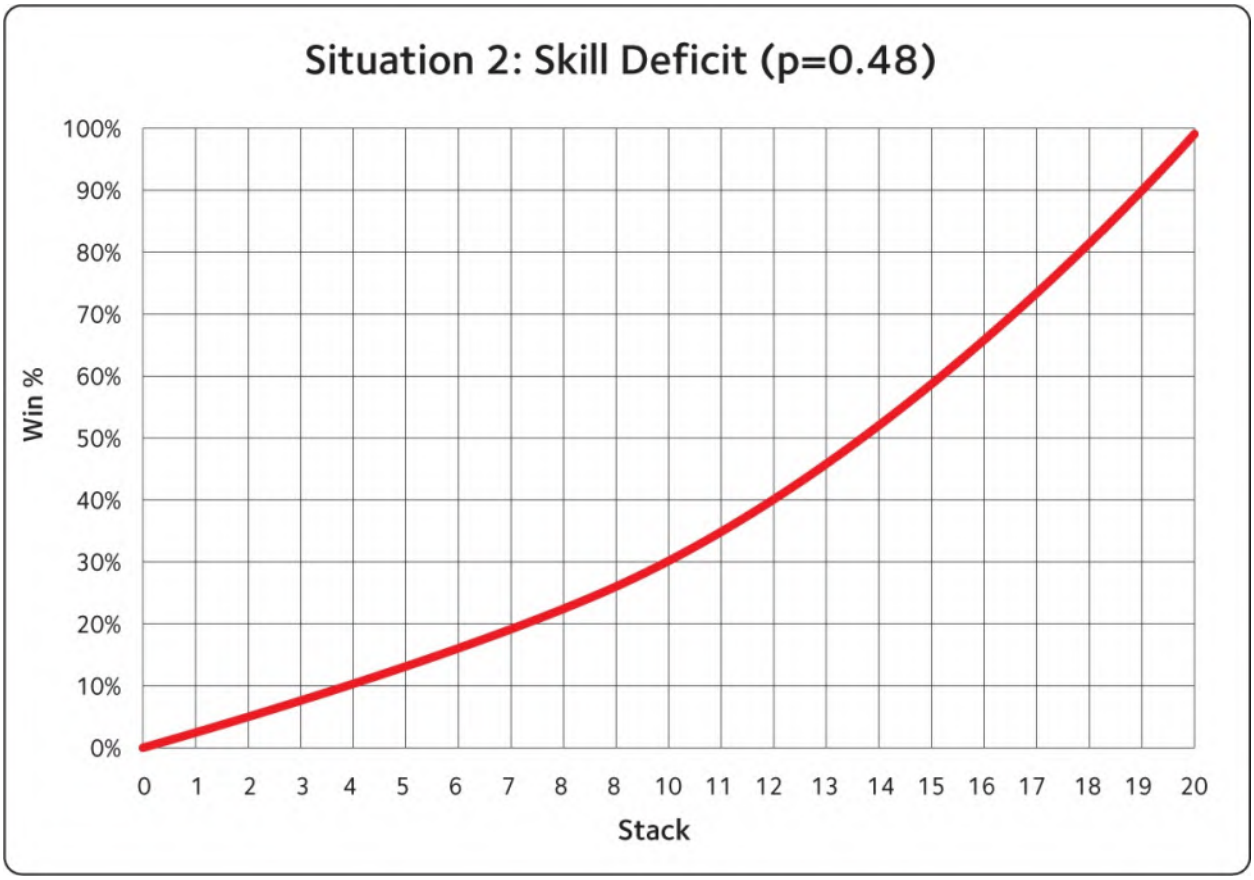


Diagram 22: Skill Deficit (p=0.48)

From the Gambler's Ruin problem, we can conclude that if Hero has a skill edge, they should be more risk averse and avoid marginal gambles. Conversely, if they have a skill deficit, they should be more willing to gamble for big chunks of their stack.

All of this makes sense intuitively. If you have a big skill edge against a bad player, you shouldn't be too eager to get all-in with a flip pre-flop for a zillion big blinds when you can slowly grind them down by playing post-flop and capitalizing on the mistakes they will make. Gambling it out for a lot of chips in marginal spots and increasing the variance will only benefit the weaker player and that will give them the best possible shot at winning.

Another example can be taken from casino games where the house holds the edge. The casino would much rather you play 100 $20 blackjack hands than a single $2,000 blackjack hand. By decreasing the variance, you are almost guaranteed to lose.

Conclusion

In tournaments there are many moving parts, including, but not limited to, different table sizes,

field sizes, stack depths, blind structures, payment structures, players' skill levels, bounties, and re-buys. The existence of so many variables makes it impossible to analyze everything accurately. Unfortunately, there is not a single unified model that covers all of these factors completely, and creating a model that can account for every single variable is almost impossible. Furthermore, even if such an algorithm existed, not even the most powerful modern super-computers would be able to calculate the solution and provide perfect strategies.

This is the reason why there are so many different approaches to tournament poker. No one has a definite answer to what "optimal" play is, particularly with the high variance that is intrinsic to MTTs. Simply copying the "winning formula" from the latest big MTT winners isn't enough to become a long-term winning player. It is often the case that the best players in the world are using strategies so unique to themselves and their metagame that blindly trying to copy them can be detrimental and produce negative results.

In poker tournaments, the chips monetary value is not fixed, so the equilibrium isn't static. It is actually dynamic. The equilibrium is constantly moving and the best MTT players in the world are the ones who really understand this concept and are capable of shifting gears, knowing when to pass on small edges and when push them. This skill is particularly difficult to master, and while a few players are naturally talented and gifted, most of us have honed this ability after years of play and study, trial and error, and victories and losses.

I dare say that this is probably the single most important skill for any MTT player to possess. All the models described in this chapter are aimed to improve your understanding of the difference between tournaments and cash games, about the differences between cEV and $EV, and the importance of tournament life. The goal is to use the equilibrium strategies presented in the upcoming text as a starting point and be capable of developing your own judgment to decide when to follow them and when to deviate in order to maximize profit.

07

MTT EQUILIBRIUM STRATEGIES: PLAYING FIRST IN

The equilibrium strategies presented in this chapter were generated with modern solvers and

super-computers, based on cEV for 9-max tables with a 12.5% ante. This is a typical tournament environment, but it is up to you to adapt them to your respective games.

In tournaments, players have to navigate many different stack sizes but, unfortunately, there is a limit to the content that can be included in a single book, so we will focus our study on some the most important stack depths where most of the tournament action happens (these being 15bb, 25bb, 40bb and 60bb).

For deep-stacked no-ante situations (typically the first few levels of a tournament) there is less dead money in the pot, so ranges are generally tighter and the equilibrium strategies are very similar to those of cash games except there is no rake. This results in speculative hands increasing in value. Calling bets and playing post-flop becomes more attractive.

Playing First In

As mentioned previously, with stack depths shorter than 10bb, it is correct to play a push/fold game because the EV loss with short stacks is negligible compared to a more complex strategy.

It is vitally important that you think ahead before making your pre-flop decision. Take note of your own stack depth as well as the players remaining to act and their stack depths. Assess the likelihood of them re-raising or calling.

You should know before you raise if your hand is a raise-fold or a raise-call. It could be the case that your hand can call an all-in against the range from one position but not from another, or that you can call a 15bb all-in but not a 20bb all-in. You also need to know if your hand works better as an open shove or a min-raise so you don't find yourself in a difficult spot if you min-raise, an opponent shoves and then you don't know what to do.

> *This might seem like way too many variables to consider, especially for inexperienced players, but it is important to be always mindful and aware of your situation and to avoid autopiloting.*

There are many online players who play great poker when playing only one table but make frequent blunders when multi-tabling due to silly mistakes that could have easily been avoided by paying closer attention.

Bet-sizing

After extensive testing with solvers, my general assessment is that RFI bet-size does not have a significant impact on your bottom line as long as you are using somewhat reasonable bet-sizes

and play reasonable ranges for that bet-size. The bigger the bet-size, the fewer hands you can play profitably. If you decide to open to 3bb, you are forced to play a tighter range than if you decide to open for a min-raise, otherwise you will lose money with the bottom of your range.

The sweet spot for RFI bet-size seems to be somewhere between 2bb and 2.5bb from BN to UTG, and 2.5bb to 3.5bb in blind vs blind battles.

I recommend min-raising when stack depths are in the rejam region (less than 25bb) for two main reasons:

- ♦ Raise-folding from a short stack is quite expensive and you don't want to overcommit yourself. For example, if you raise to 3x from UTG with 10bb and the BB goes all-in, you will need to call 7bb to play for a 14.6bb pot. Getting better than 2-to-1 pot odds, you will be committed to call off with any two cards in your reasonable raising range. If you instead min-raised, you would have to call 8bb into a 13.6bb pot, getting 1.7-to-1 pot odds, which allows you to fold the worst hands in your range.

- ♦ One of the main weapons players have when facing open raises with shallow stacks is to rejam all-in and, against bigger raise sizings, the Villains will get a better price on their rejams. For example, if you are in the CO and open to 2.5x with a 20bb effective stack, the BB has to risk 19bb to win 5.125bb. This bet needs to work

$$\frac{19}{(19+5.125)} = 78.76\%$$

of the time. If instead you open to 2x, this bet needs to work

$$\frac{19}{(19+4.625)} = 80.42\%.$$

Your 3-bet and squeeze sizings will vary according to the player's position and stack depth as shown in *Tables 43 and 44*.

Stack Depth (bb)	IP	SB	BB	Versus Open
<20	All-in	All-in	All-in	2x
20-23	All-in / 5bb	All-in / 5.5bb	All-in / 5.5bb	2x
24-27	All-in / 5.5bb	All-in /6.5bb	All-in /6.5bb	2x
28-35	6	All-in /7bb	All-in /7bb	2.3x
36-45	7	8	8	2.3x
46-65	7.5	9	9	2.3x
66-99	8	9.5	9.5	2.3x
100+	8.5	10	10	2.5x

Table 43: MTT Recommended 3-bet Sizings

Stack Depth (bb)	IP	SB	BB	Versus Open
<20	All-in	All-in	All-in	2x
20-23	All-in / 6bb	All-in	All-in	2x
24-27	All-in / 6.5bb	All-in /7bb	All-in /7bb	2x
28-35	All-in /7bb	All-in /7bb	All-in /7bb	2.3x
36-45	8	All-in /10bb	All-in /10bb	2.3x
46-65	8	10	10	2.3x
66-99	10	12	12	2.3x
100+	10	13.5	13.5	2.5x

Table 44: MTT Recommended Squeeze Sizings

At stack depths 30-35bb and greater, the threat of getting rejammed is lower because of the higher risk/reward ratio. This means you can increase your raise size to 2.3x and not worry too much about giving the Villains a better price on their rejams. By increasing your raise size, you cut down the Villain's implied odds, making it tougher for them to peel with the weaker hands in their range. With 100bb+, the RFI size can be 2.3-2.5x; I've seen some regs going bigger than that, but I haven't found substantial evidence that going any bigger yields a higher EV.

In general, you want to have bigger bet-sizes when deep stacked and when out of position. I like using a smaller 3-bet size from the SB than from the BB, because the SB has to worry about the BB waking up with a hand, so the smaller sizing saves a few chips when this happens. Also,

the SB 3-betting range is in general less polarized than the BB, so it doesn't mind getting called as much as the BB does.

If the 3-bet size requires you to invest over 1/3 of your stack, you will be pot-committed unless your hand is absolute trash, so I wouldn't recommend investing over 1/3 of your stack with a terrible hand. In that case, you are better off going all-in instead, reducing your opponent's strategic options to calling the all-in or folding.

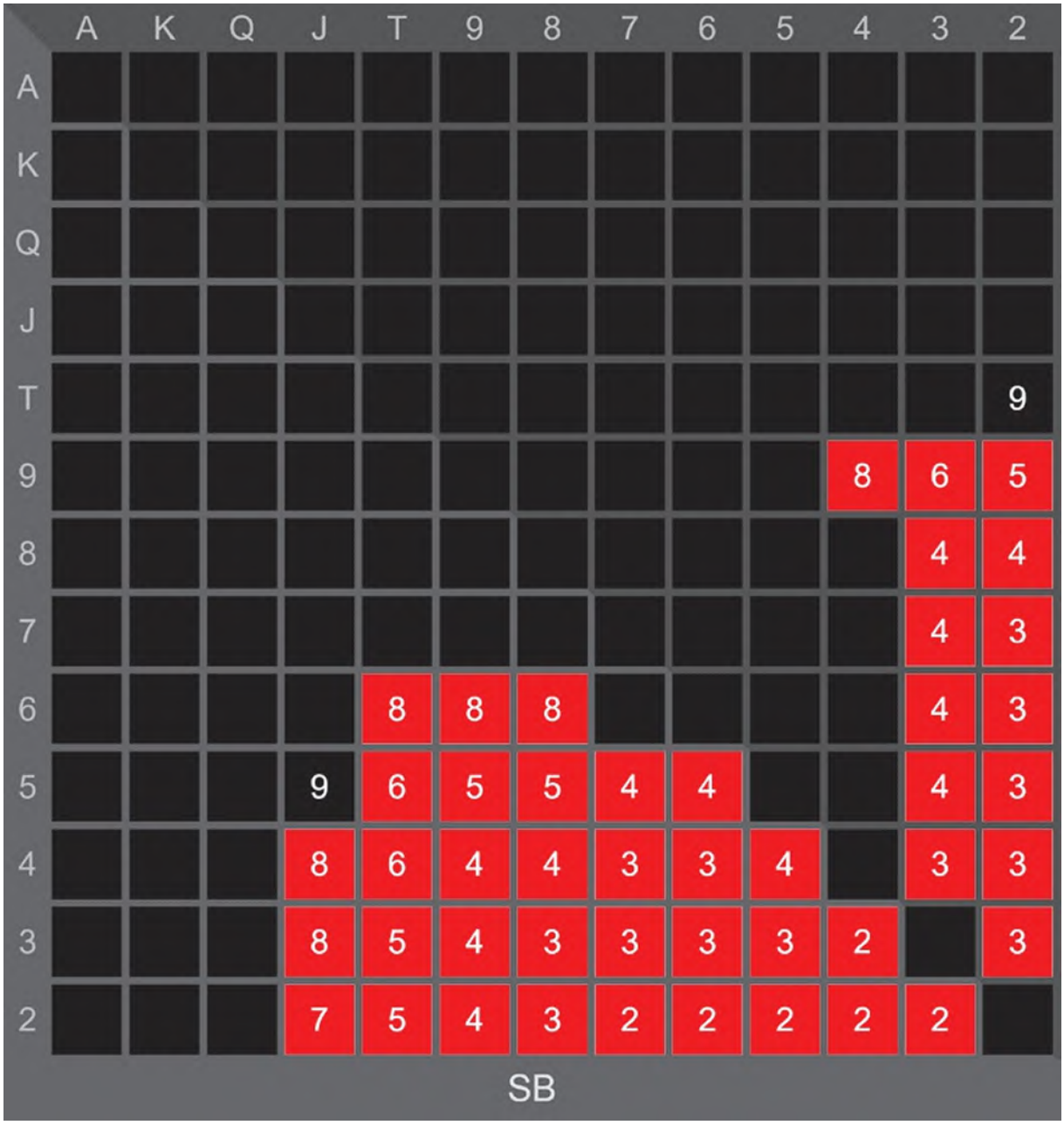
With fewer than 40bb, all 4-bets are only all-in because if you choose non-all-in 4-bet-sizes you would either be pot-committed or would have to use an extremely small size, which will give the Villains too good of a price to take the flop and realize equity. With 50bb to 100bb, you start to see non-all-in 4-bets to 2.25-2.5x when IP and 2.5-3x when OOP. All 5-bets are always all-in.

In modern online MTTs, some players still use smaller bet-sizes than recommended. This is mostly because people still fold too often to small bet-sizes. However, as the games evolve, bigger bets will become the norm because players now understand that calling small raises and realizing equity is always an option. This is the reason why the old silly click-back 5-bets and 6-bets are now pretty much extinct.

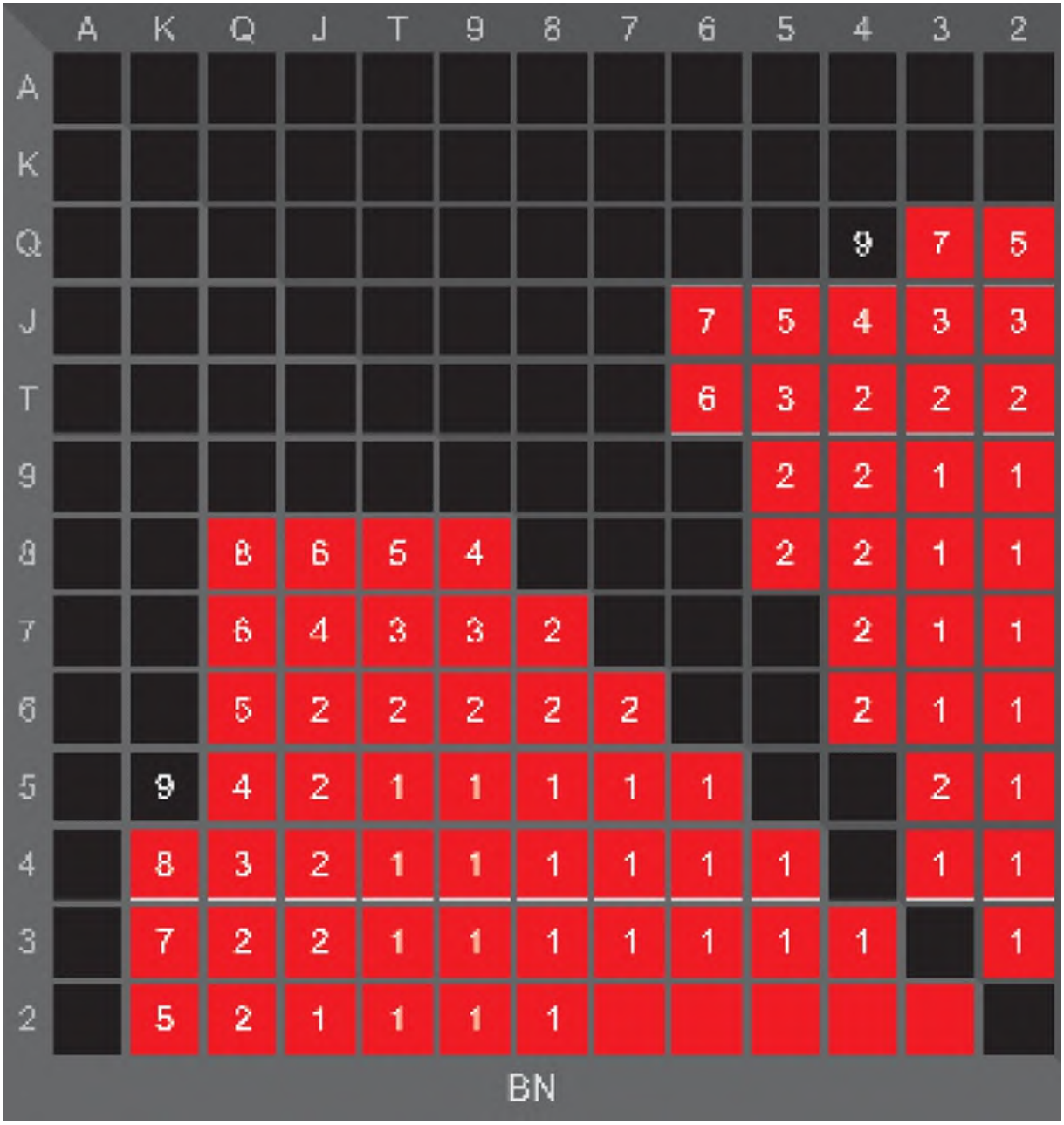
As explained in the General Guidelines for Pre-flop Bet-sizing section in Chapter 4, the earlier the position the smaller your bet-size should be, so use a slightly smaller bet RFI and 3-bet sizes from EP. Increasing your bet-size as you move closer to the BN is a valid strategy that I use in my games, but it comes at a cost of increasing the complexity of your strategies and I haven't found solid evidence of this having a really large impact on your bottom line. So, using a simpler, easier to execute strategy with fewer bet-sizes is recommended.

Short Stack Push/Fold Charts

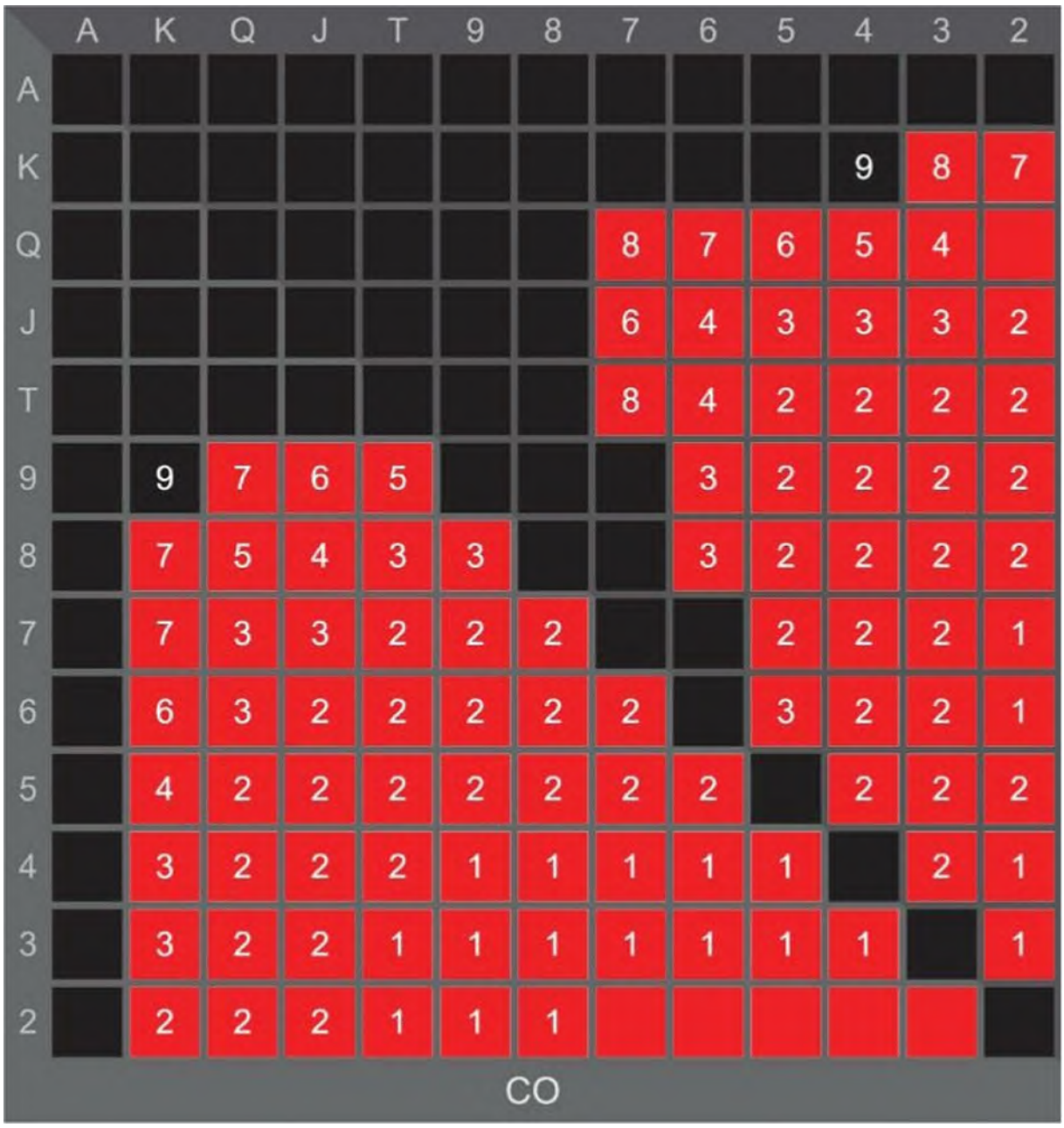
The following charts *(Hand Ranges 88-95)* were generated with HRC using FGS. The numbers in the cells represent the maximum number of big blinds that can be pushed with that hand for each position. Hands in black can be pushed when having 10bb or less. For example, the SB can only push 95o with 5bb or less, but can push 95s with 10bb or less.



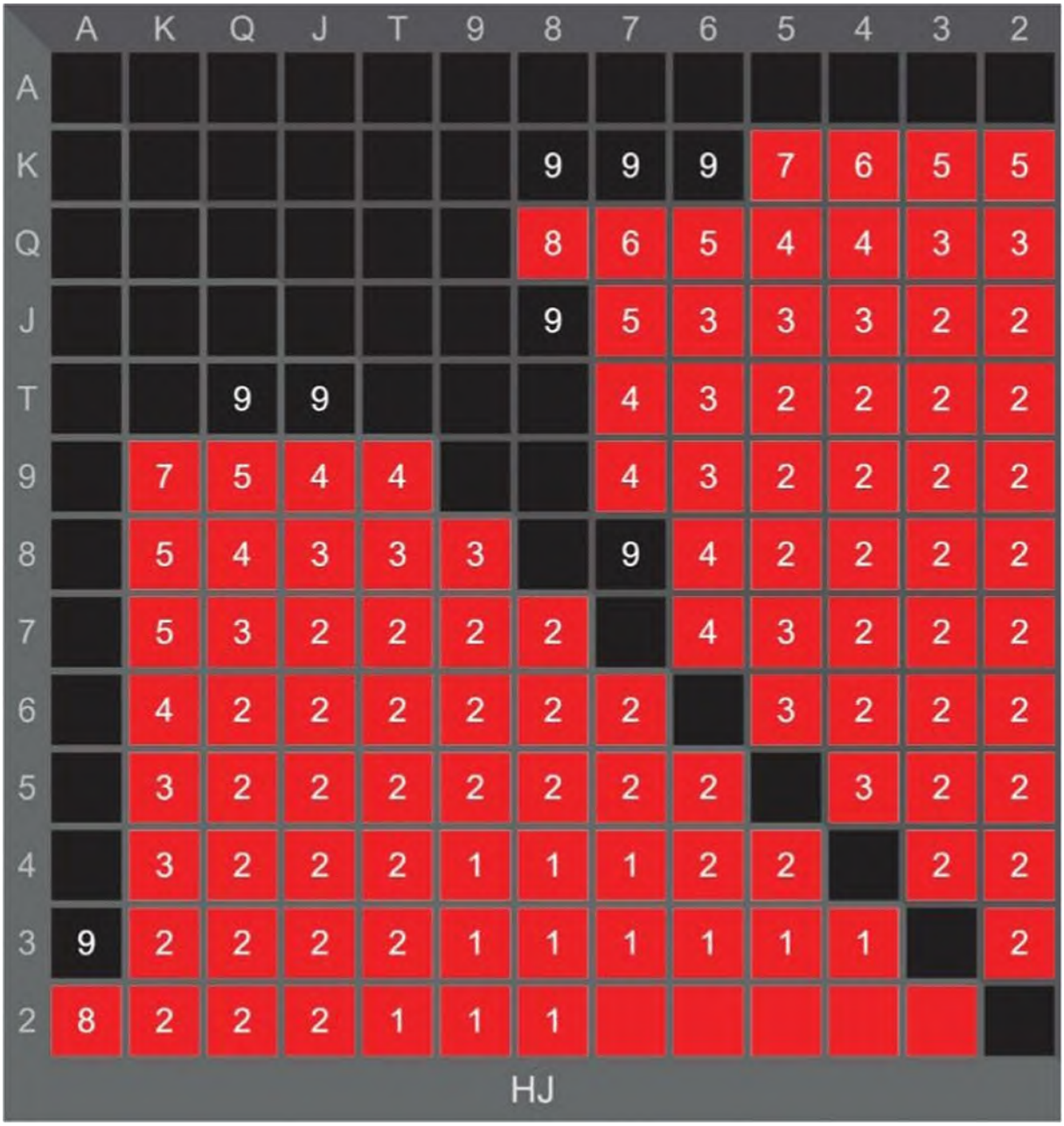
Hand Range 88:
Stack Depths for SB Push



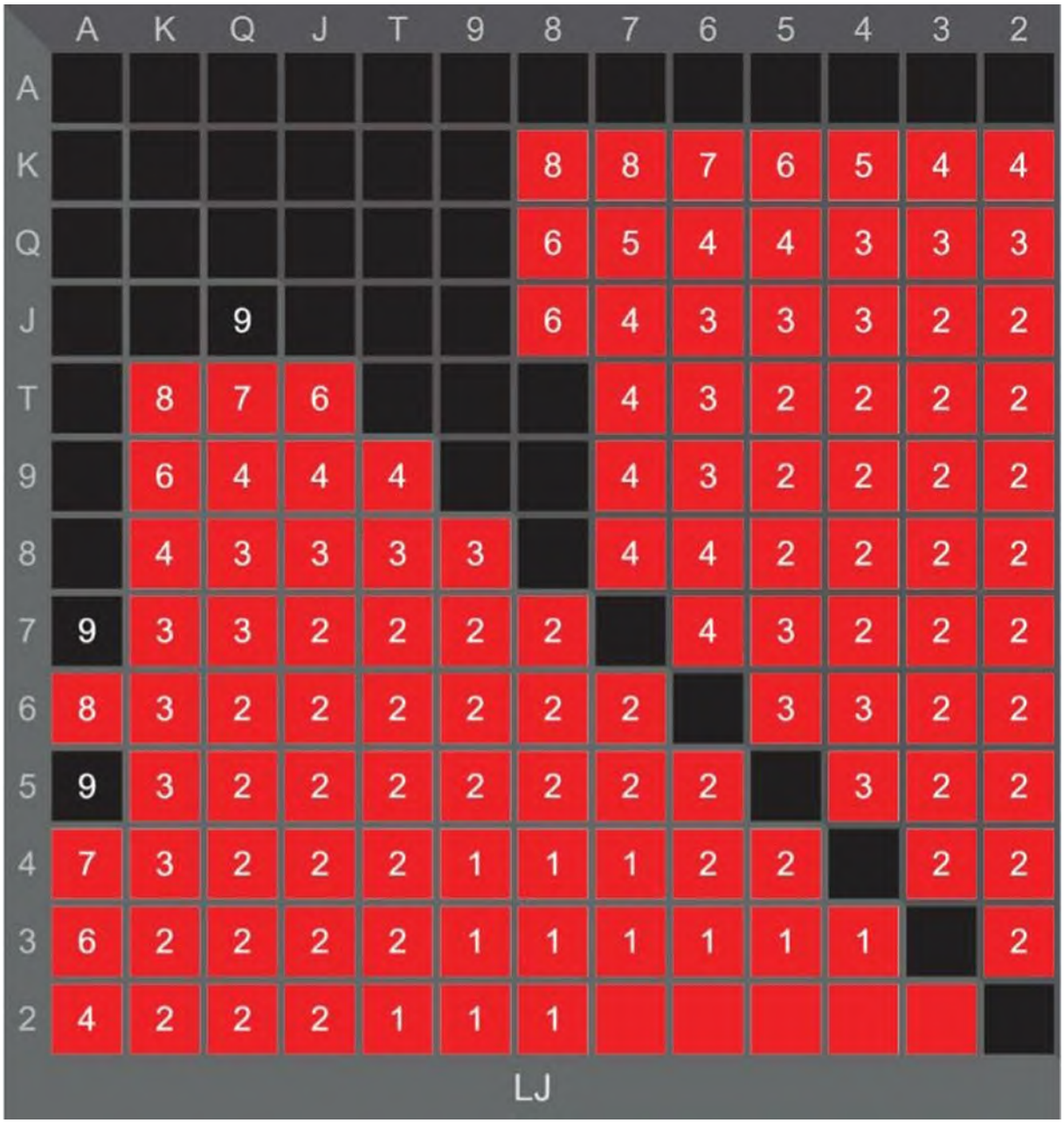
Hand Range 89:
Stack Depths for BN Push



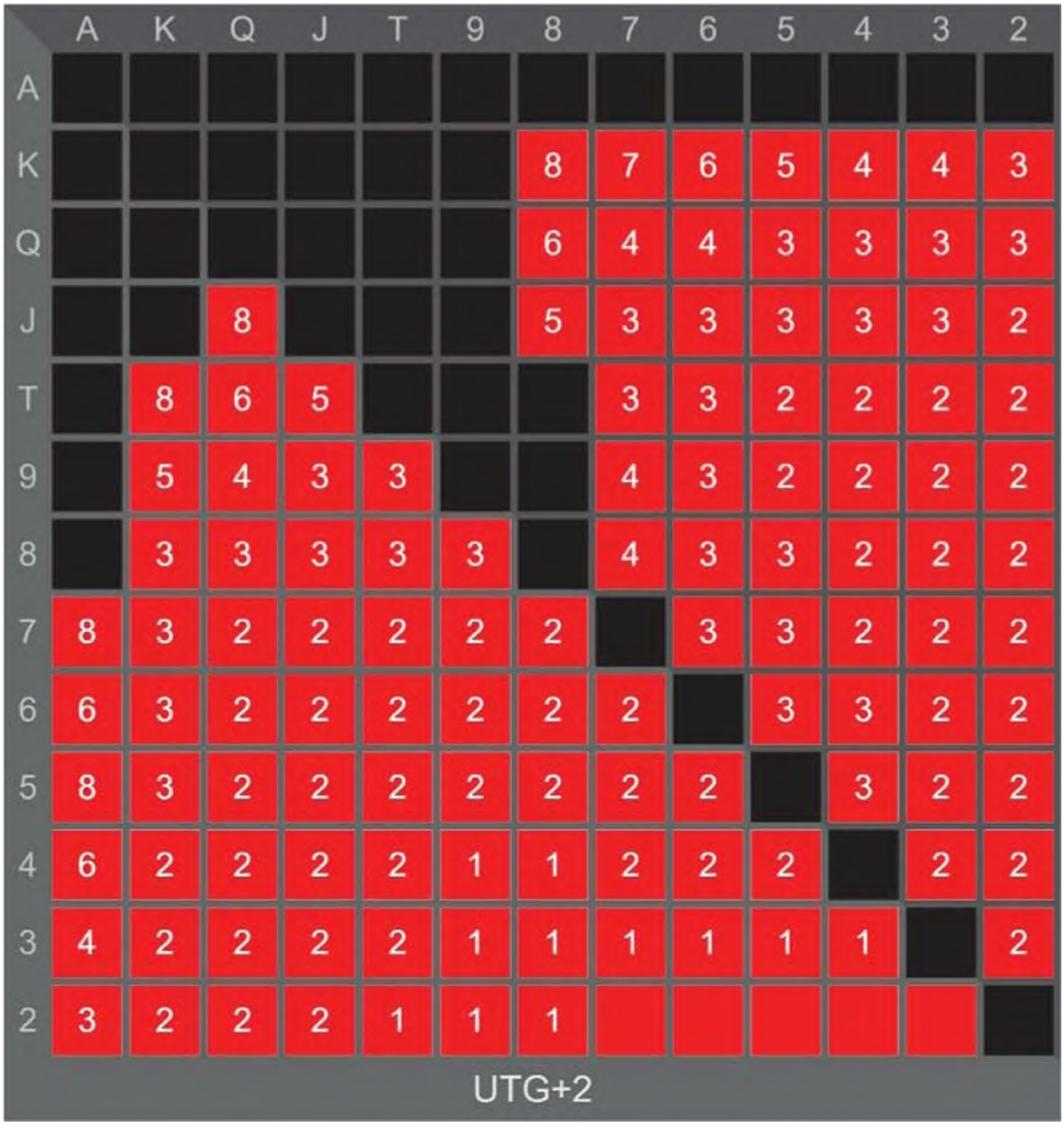
Hand Range 90:
Stack Depths for CO Push



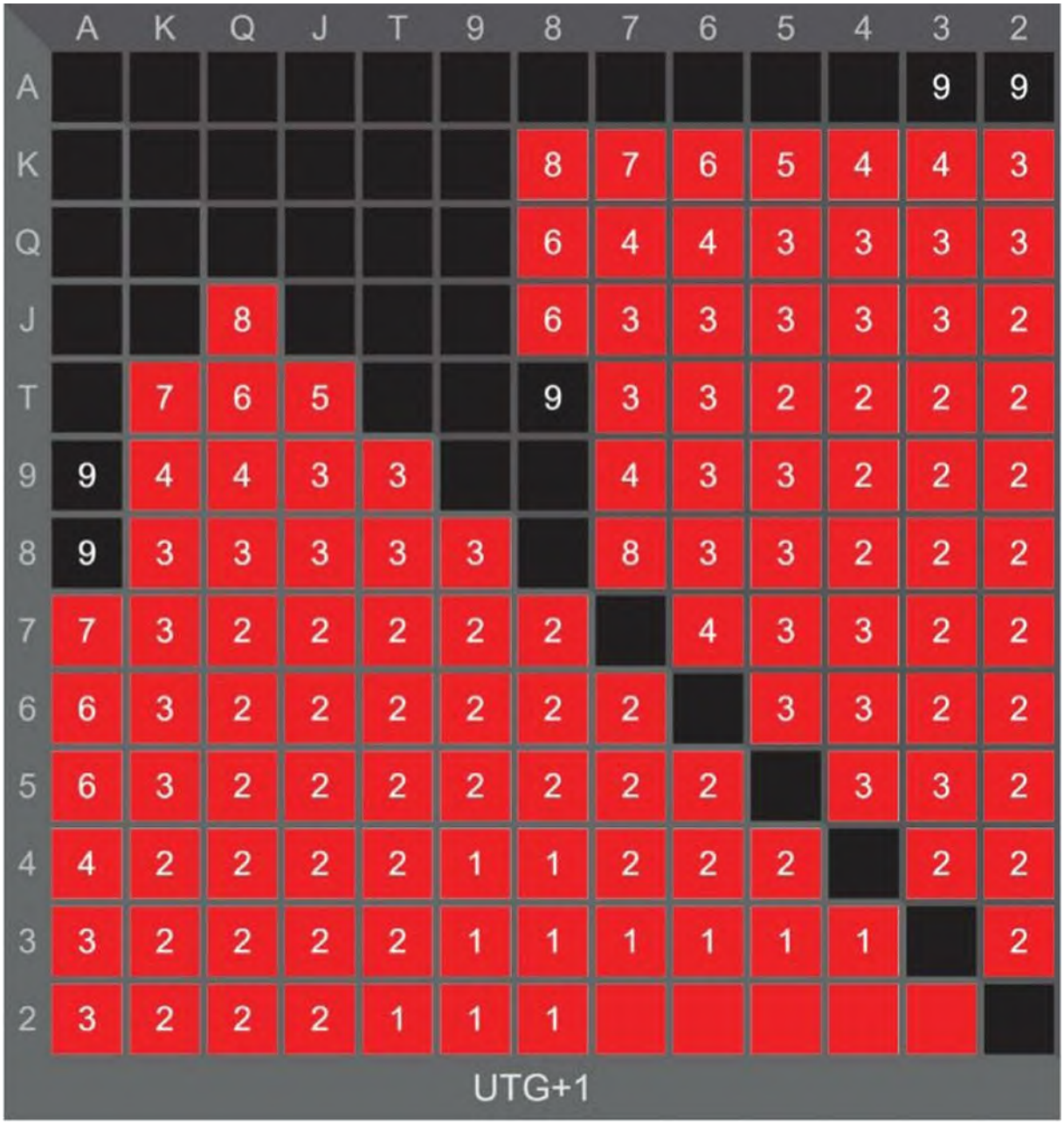
Hand Range 91:
Stack Depths for HJ Push



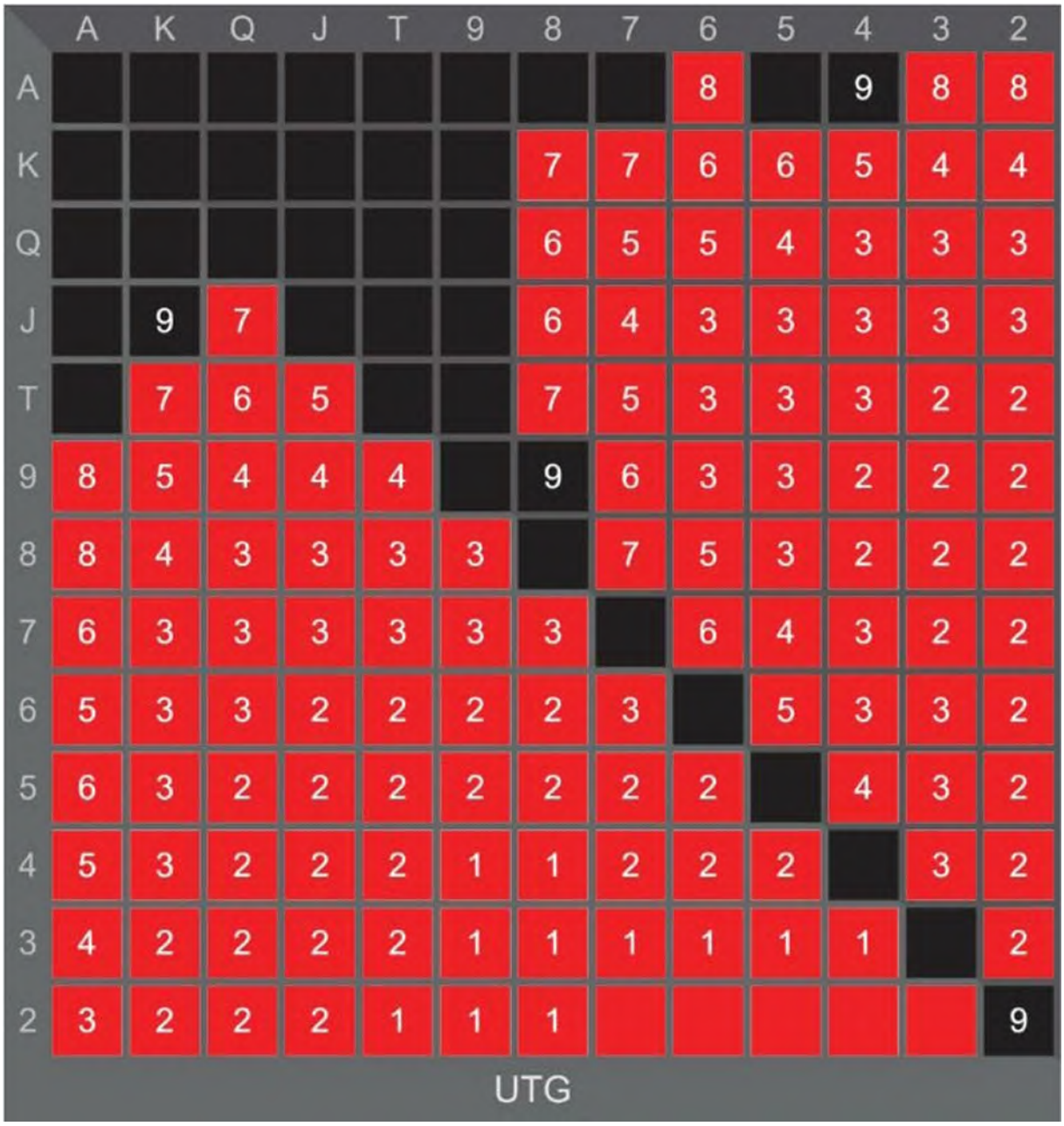
Hand Range 92:
Stack Depths for LJ Push



Hand Range 93:
Stack Depths for UTG+2 Push



Hand Range 94:
Stack Depths for UTG+1 Push



Hand Range 95:
Stack Depths for UTG Push

We now move on to examine the best way to react when the action is folded to you. We will consider all positions from the small blind round to UTG and all different stack depths from 10bb to 80bb.

Small Blind PFI Strategy

The SB is the position where you get to VPIP the largest number of hands when it folds to you (83% on average). This is due to the fact that the SB has a discount to enter the pot and has to worry about only one player left to act. *Table 45* is a summary of SB GTO Action Frequencies by stack depth:

SB	Actions Frequency				Total VPIP
Stack	All-in	Raise (Non All-in)	Limp	Fold	
10bb	51.00%	0.00%	28.60%	20.40%	79.60%
12bb	42.20%	0.00%	40.00%	17.70%	82.30%
15bb	23.70%	0.00%	61.50%	14.80%	85.20%
17bb	18.00%	16.3% (2.5x)	50.10%	15.60%	84.40%
20bb	13.00%	17.3% (2.5x)	54.80%	14.90%	85.10%
25bb	1.80%	29.8% (3.3x)	50.50%	17.90%	82.10%
30bb	0.00%	31.8% (3.5x)	48.20%	19.90%	80.10%
40bb	0.00%	26.4% (3.5x)	54.40%	19.20%	80.80%
60bb	0.00%	15.1% (3.5x)	69.90%	15.00%	85.00%
80bb	0.00%	12.0% (3.5x)	74.80%	13.20%	86.80%
				Avg VPIP	83.14%

Table 45: SB GTO Action Frequencies by Stack Depth

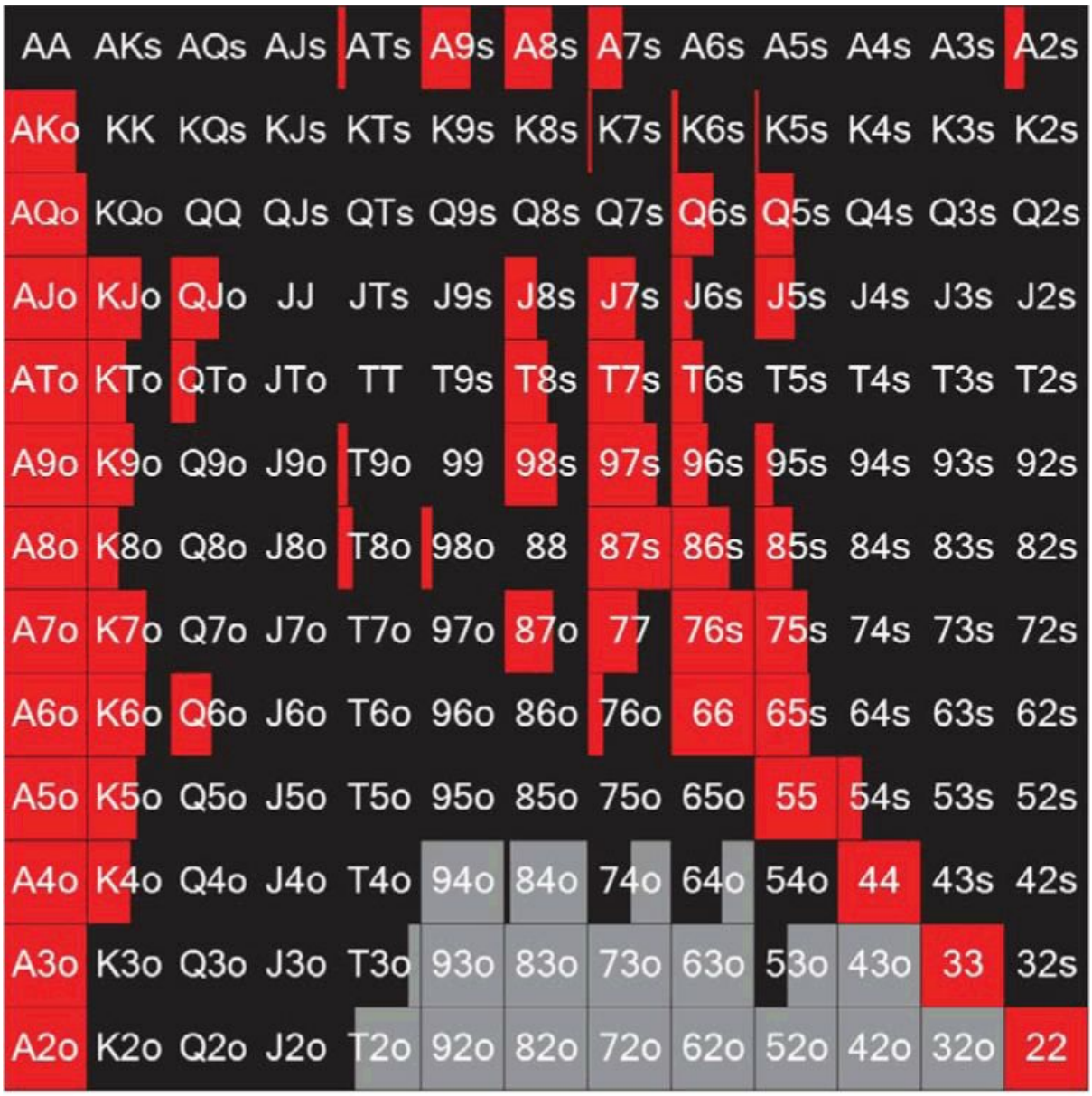
Small Blind Strategy at 15bb

With 10-15bb stacks, play a push/limp/fold strategy and as stacks get deeper, you should push fewer hands, resulting in limping becoming the dominant strategy.

At 15bb, the solver likes to push hands that have good blockers such as Ax, Kx, and hands that have a lot of equity against calling ranges but bad post-flop EqR, such as small pocket pairs (66-22), and hands that have a ton of equity but would struggle to call a jam themselves such as suited connectors (98s-65s). The limping range consists of high equity hands that can call an all-in, such as pocket pairs (77+), broadways, suited Ax and Kx and hands such as Q2o, J8o, T4s and 73s that have fine equity in limped pots but don't mind limp-folding against a jam *(Hand Ranges 96-98)*.

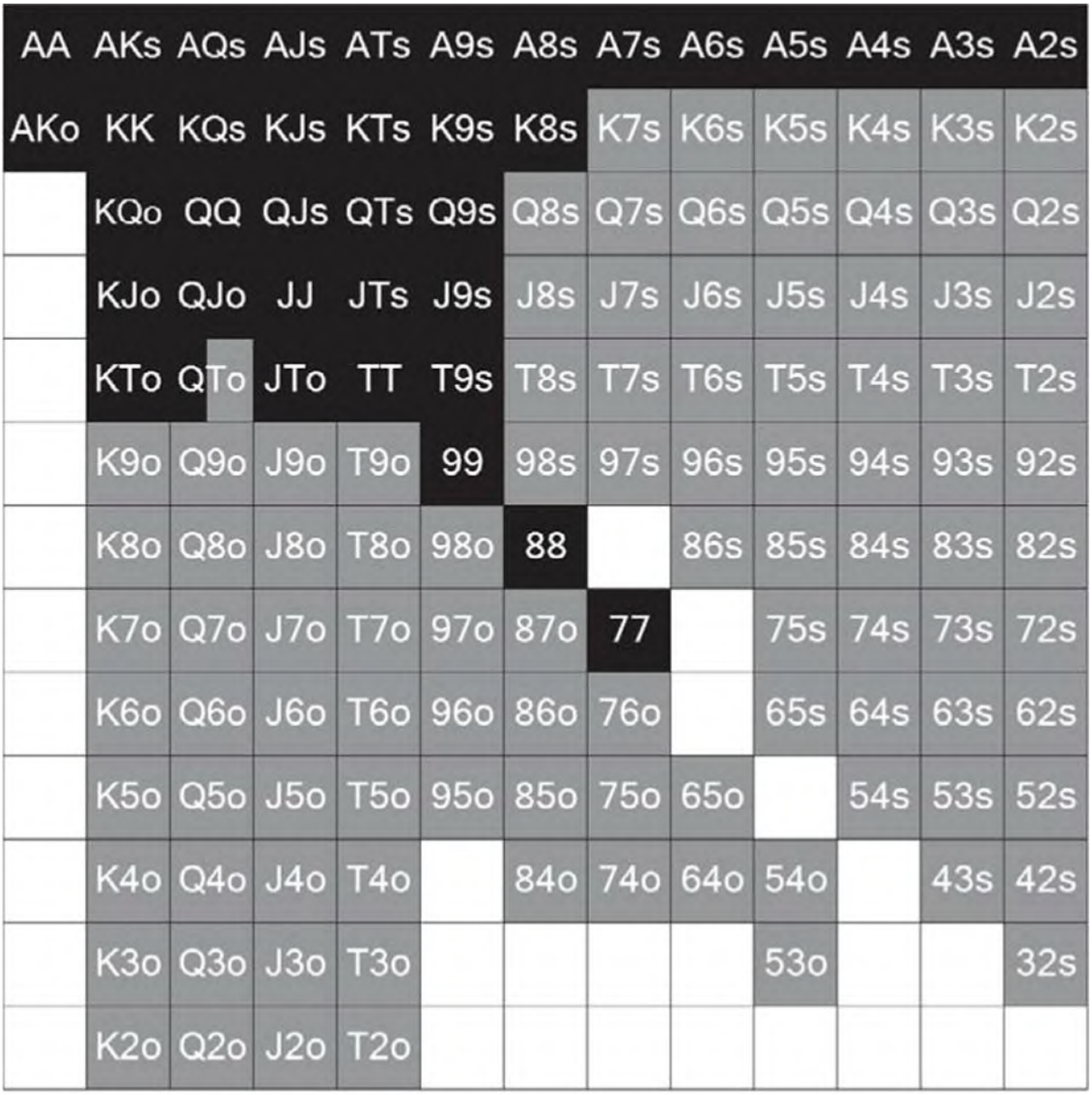
At 17bb, the SB starts to have a non-all-in raise size, and the raise size gets bigger as stacks get deeper, from 2.5x at 17bb to 3.5x at 30bb. At deeper stacks, the solver likes to use even

bigger raise sizes (up to 5x) but there is no substantial EV loss by using 3.5x, and so I believe that using sizes bigger than 3.5x is overkill.



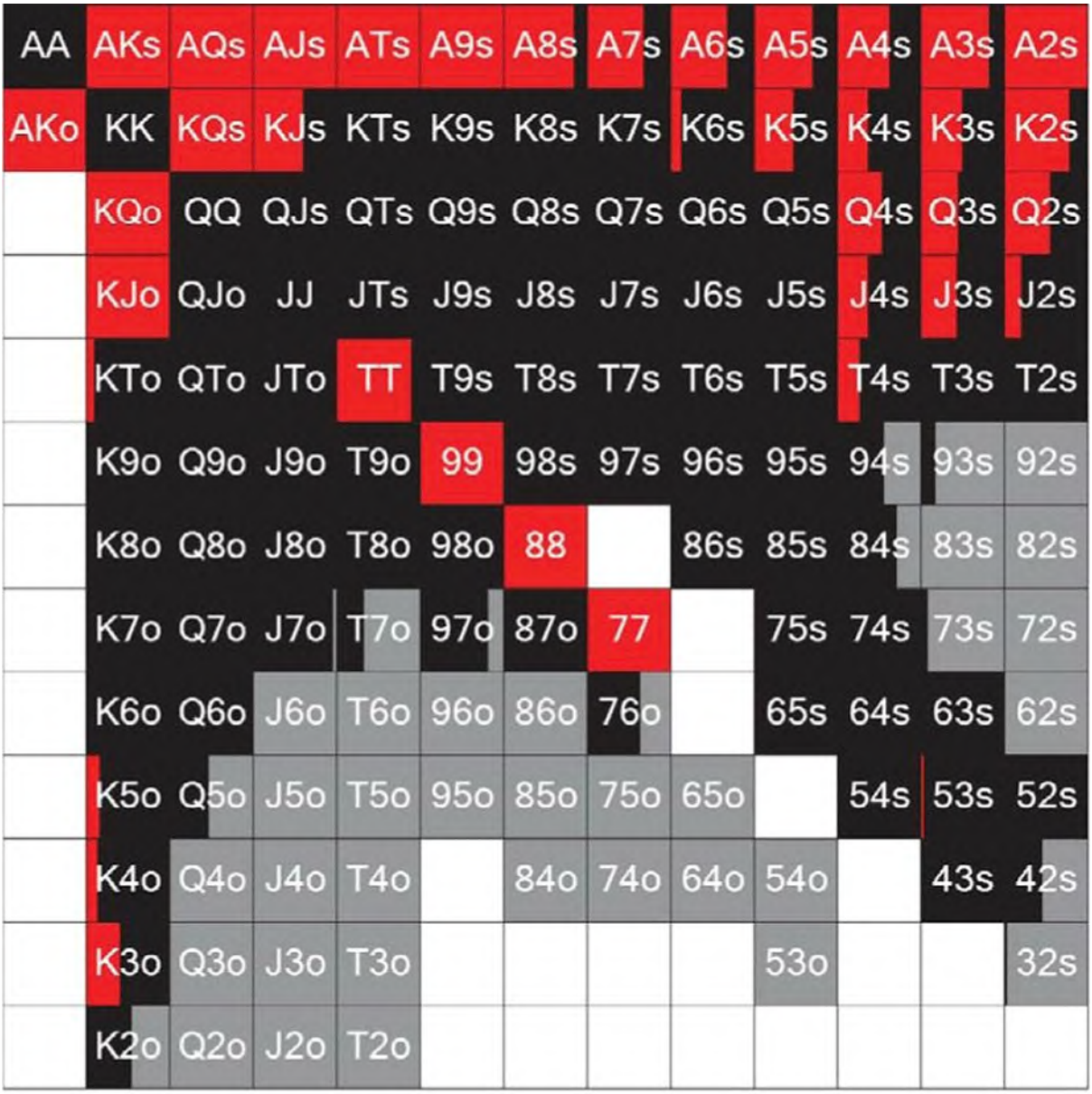
Hand Range 96: SB vs BB (15bb)

• All-in 23.7% / • Limp 61.5% / • Fold 14.8%



Hand Range 97: SB vs BB 15bb (Limp vs All-in)

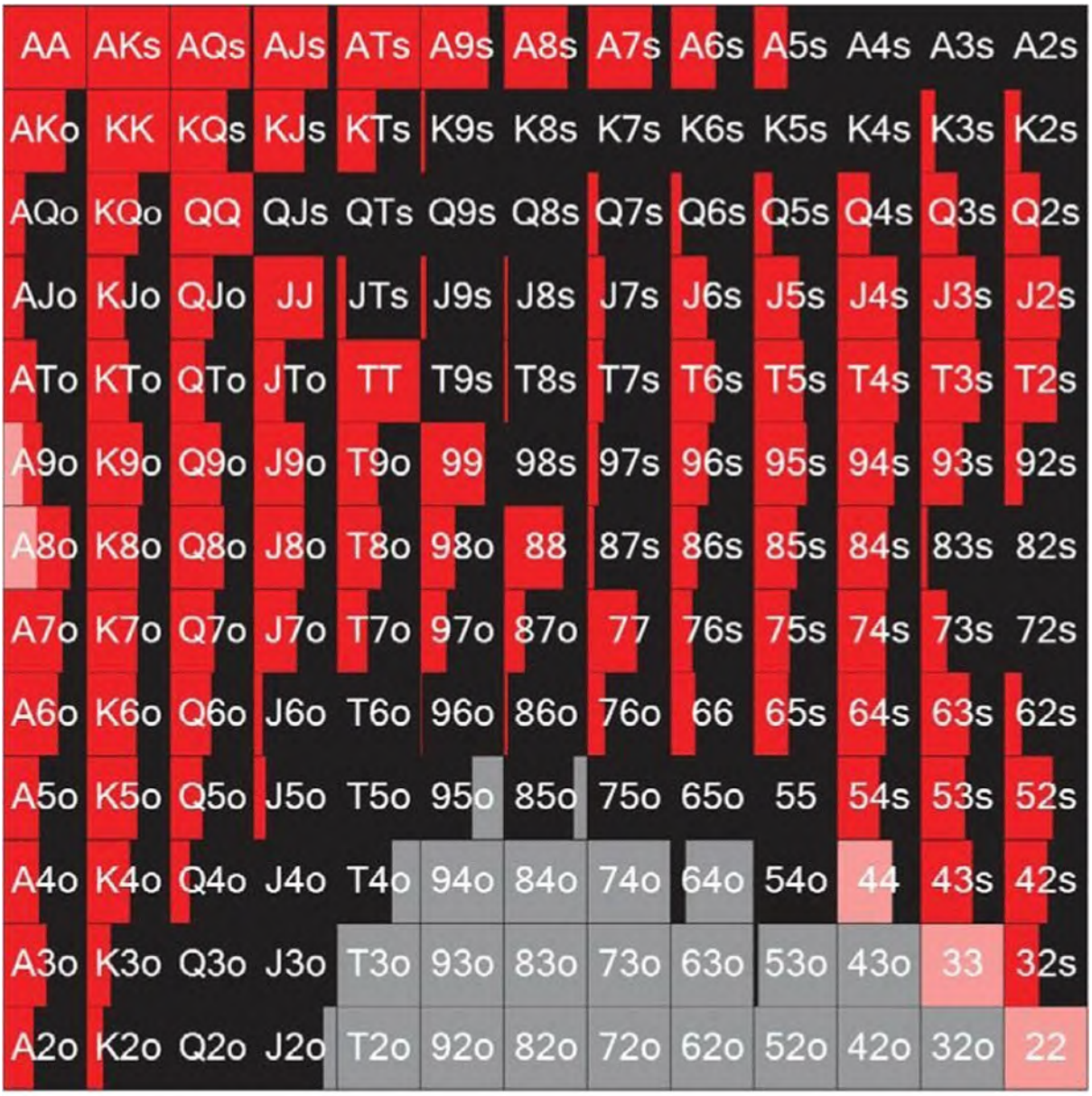
• Call 21.3% / • Fold 78.7%



Hand Range 98:

SB vs BB 15bb (Limp vs 3x Raise)

• All-in 12.9% / • Call 49.1% / • Fold 38%



Hand Range 99: SB vs BB (25bb)
• All-in 1.8% / • Raise 3.3x 30% /
• Limp 50.3% / • Fold 17.9%

Small Blind Strategy at 25bb

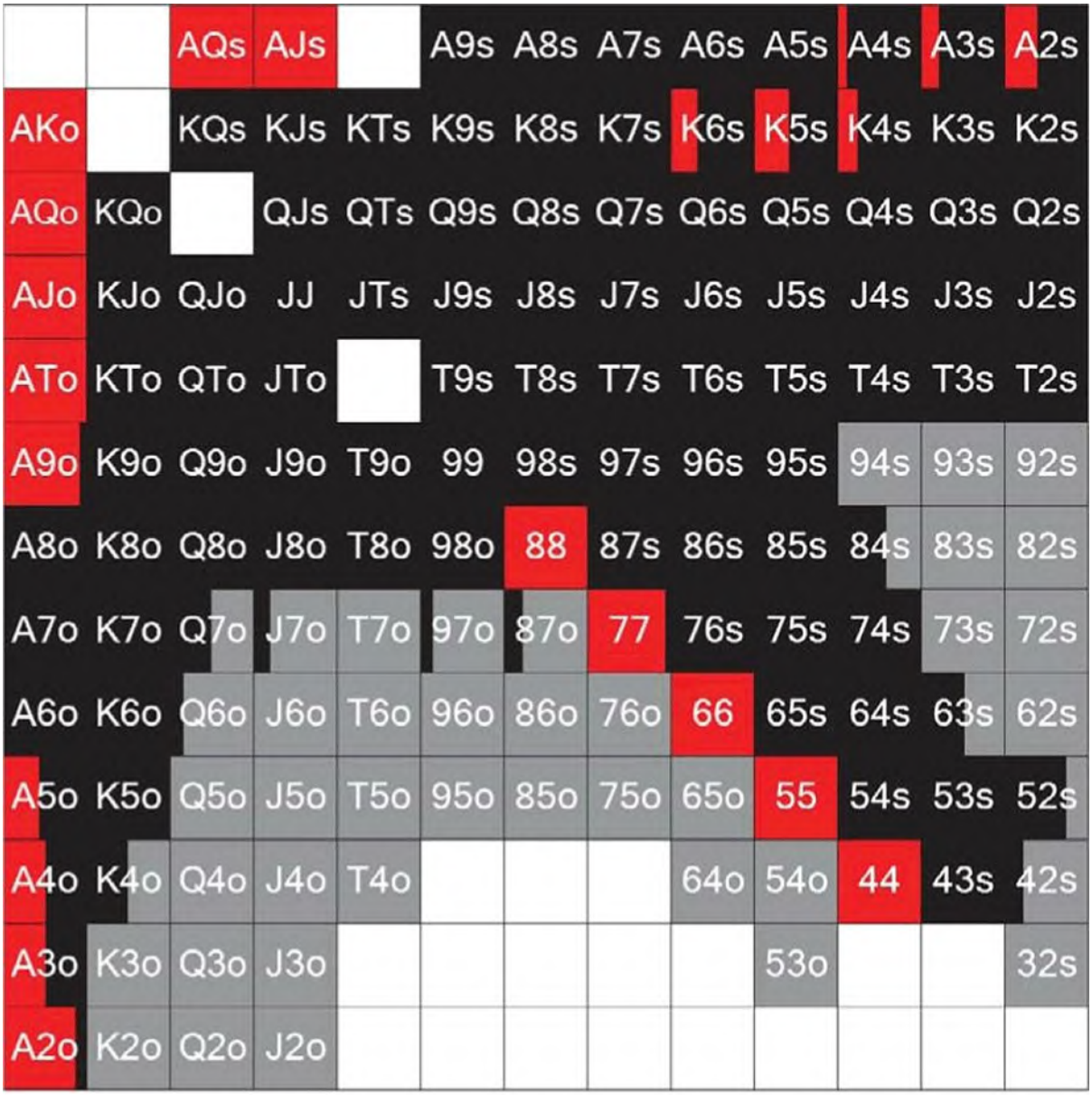
At 25bb, the SB open pushing range starts to disappear. The only hands that want to open push are baby pairs (44-22) and some offsuit mid Ax (A9o, A8o). The strategy becomes raise/limp/fold *(Hand Range 99)*.

The limping range is made of some traps with the strongest Ax (AKo-A9o), mid pocket pairs

(99-44) and many hands with good equity that don't want to raise and be forced to fold against a jam, such as KTo, Q9s and 76s. The raising range is again polarized and is made up of the strongest hands that can call a jam, such as pocket pairs (66+), offsuit Ax (A8o+), suited Ax (A5s+) and the strongest broadways. The rest of the raising range is focused on having a blocker, such as A7o-A2o, Kxo and hands with decent playability in single raised pots, such as KJo, QTo, J8s, and 74s. *(Hand Ranges 100-102).*

		AQs	AJs		A9s	A8s	A7s	A6s	A5s	A4s	A3s	A2s
AKo		KQs	KJs	KTs	K9s	K8s	K7s	K6s	K5s	K4s	K3s	K2s
AQo	KQo		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		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				64o	54o	44	43s	42s
A3o	K3o	Q3o	J3o						53o			32s
A2o	K2o	Q2o	J2o									

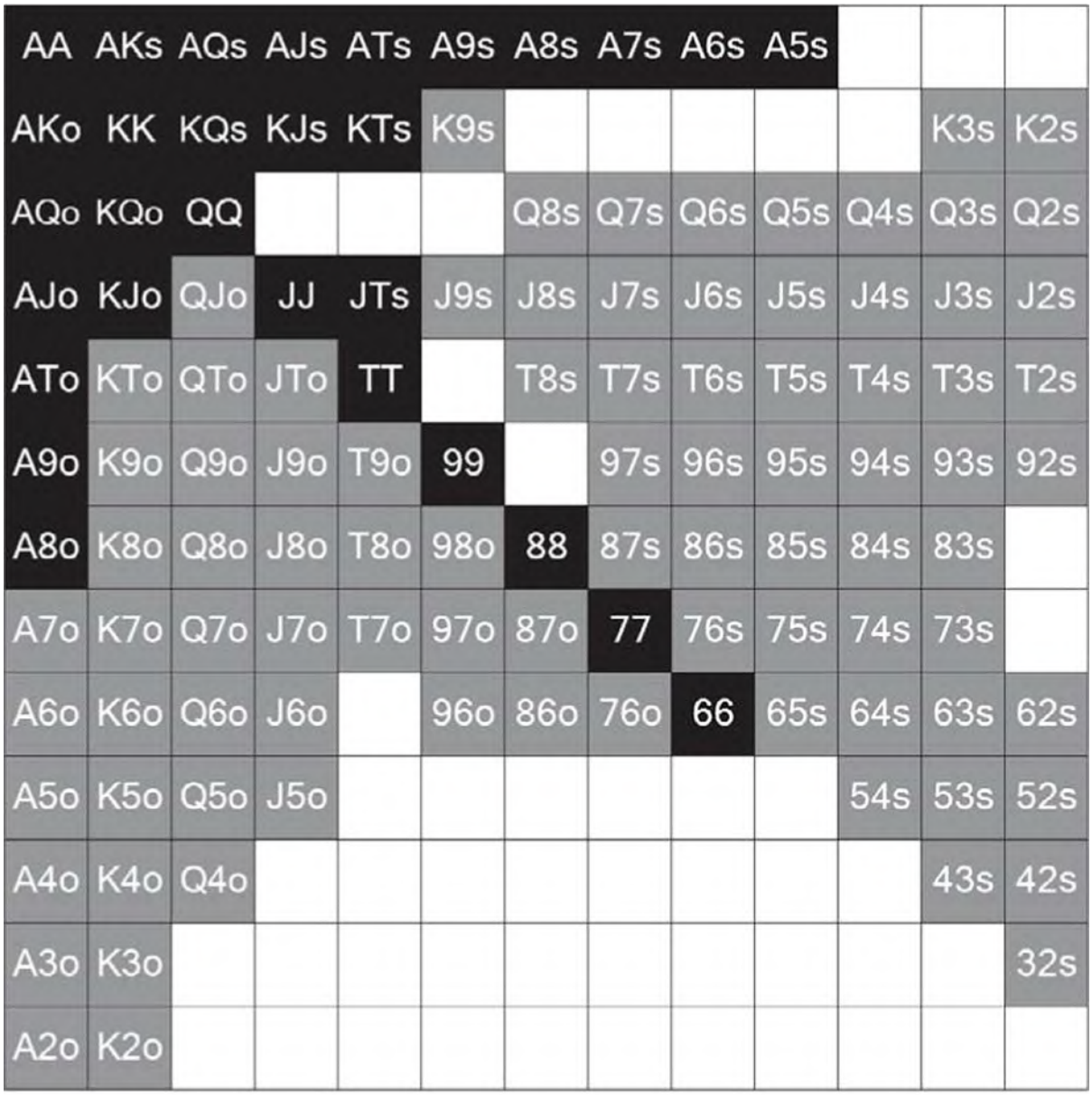
Hand Range 100:
SB vs BB 25bb (Limp vs All-in)
• Call All-in 15.2% / • Fold 84.8%



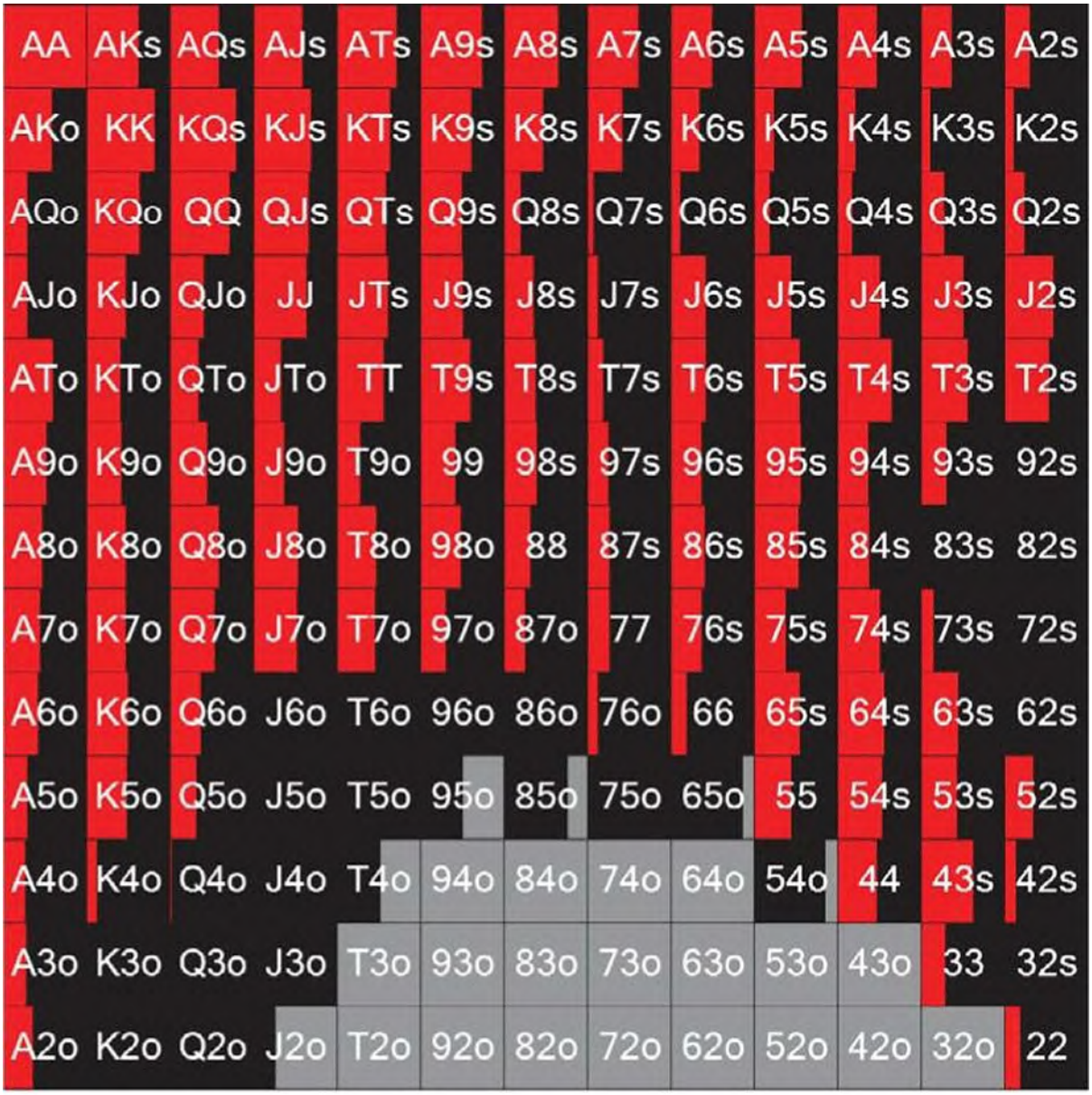
Hand Range 101:

SB vs BB 25bb (Limp vs 3.3x Raise)

• All-in 11% / • Call 43.7% / • Fold 45.4%



Hand Range 102:
SB vs BB 25bb (3.3x Open vs All-in)
• Call All-in 30.1% / • Fold 69.9%



Hand Range 103: SB vs BB (40bb)
• Raise 3.5x 26.4% / • Limp 54.4% /
• Fold 19.2%

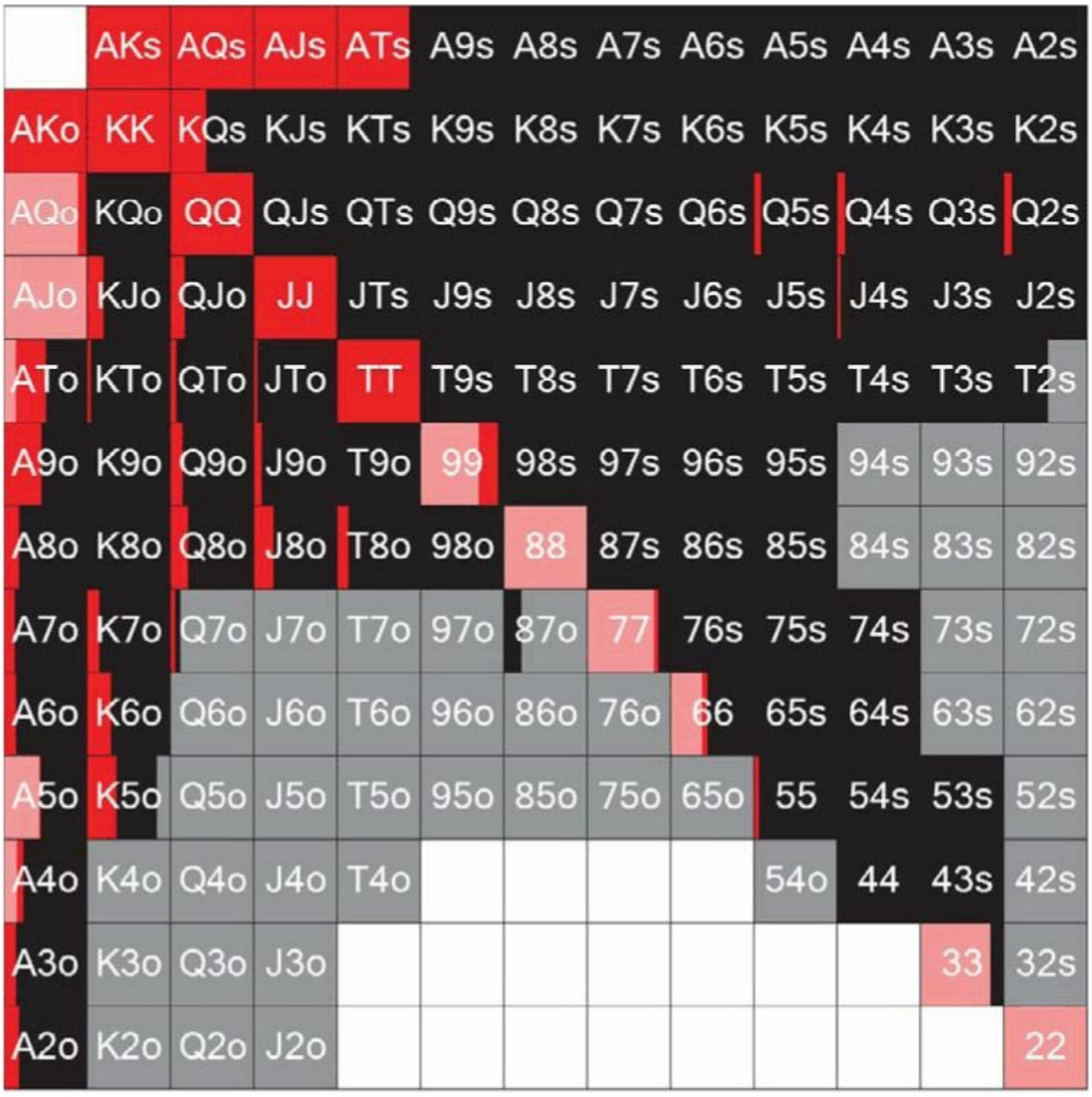
Small Blind Strategy at 40bb

At 40bb, there is no all-in range and most hands are played as a mixed strategy, with the strongest hands being raised more often than limped and the weaker hands being limped more often than raised *(Hand Range 103)*.

After limping and facing a 3.5x raise, the SB will defend by going all-in with 5.9% of their

range, including pocket pairs (99, 88, 77, 33, 22), strong Axo (AQo, AJo) and a small frequency of weak Axo (ATo, A5o, A4o).

The SB also has a non-all-in re-raise to 2.75x that includes the strongest hands that are happy to stack off pre-flop, such as 55+, AT+, and KQs, and some bluffs with good blockers such as Axo and Kxo *(Hand Ranges 104-105)*.



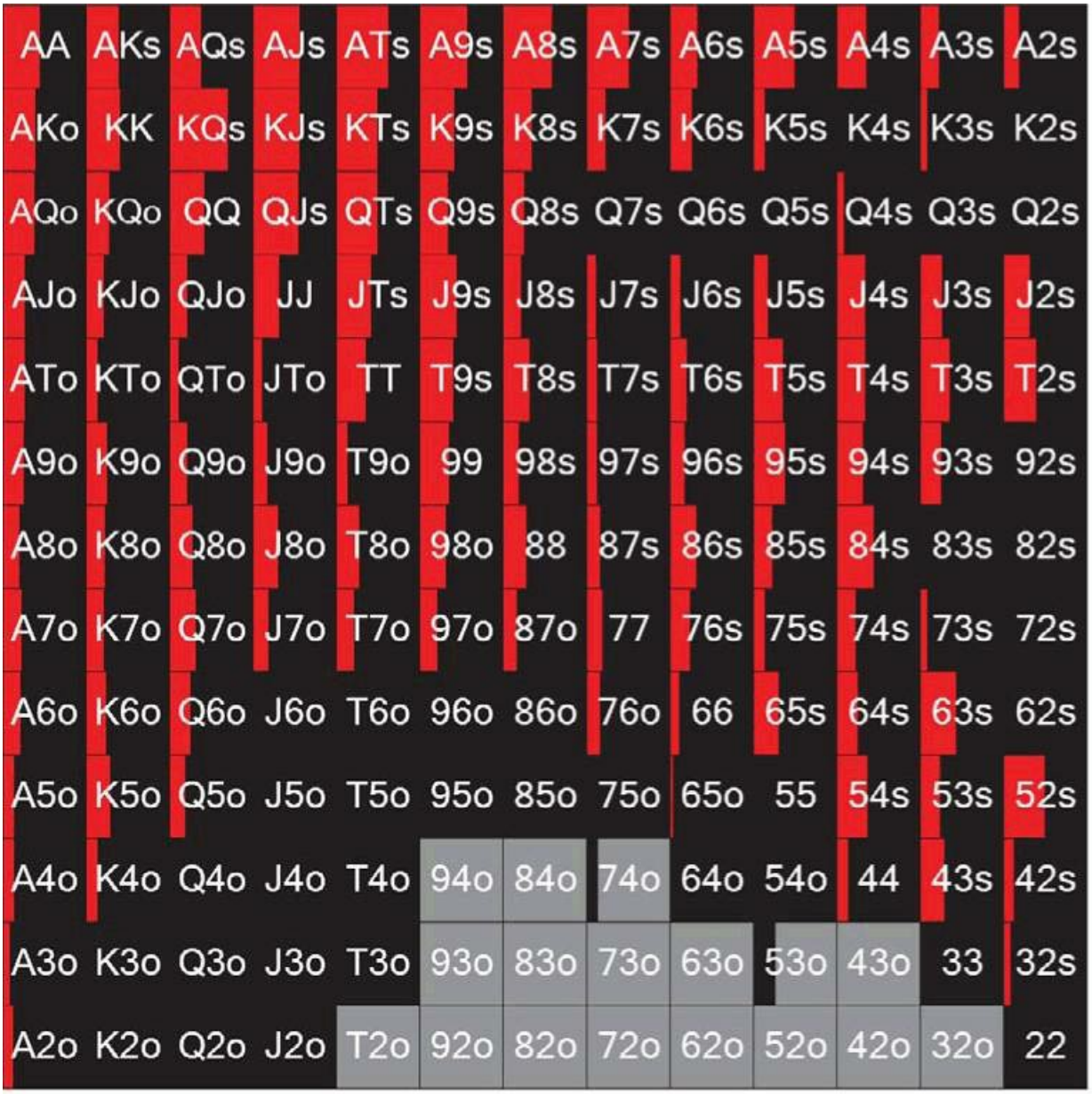
Hand Range 104:
SB vs BB 40bb (Limp vs 3.5x)
• All-in 5.9% / • Raise 2.75x 6.4% /
• Call 42% / • Fold 45.6%

Hand Range 105:
SB vs BB 40bb (3.5x Open vs 2.75x 3-bet)
• All-in 13.1% / • Call 40.4% /
• Fold 46.5%

Small Blind Strategy at 60bb

The common trend seen as stacks get deeper is the increase in the limping frequency and a reduction in the raising frequency. There aren't any hands that play a pure raising strategy, but there are many that play a pure limping strategy.

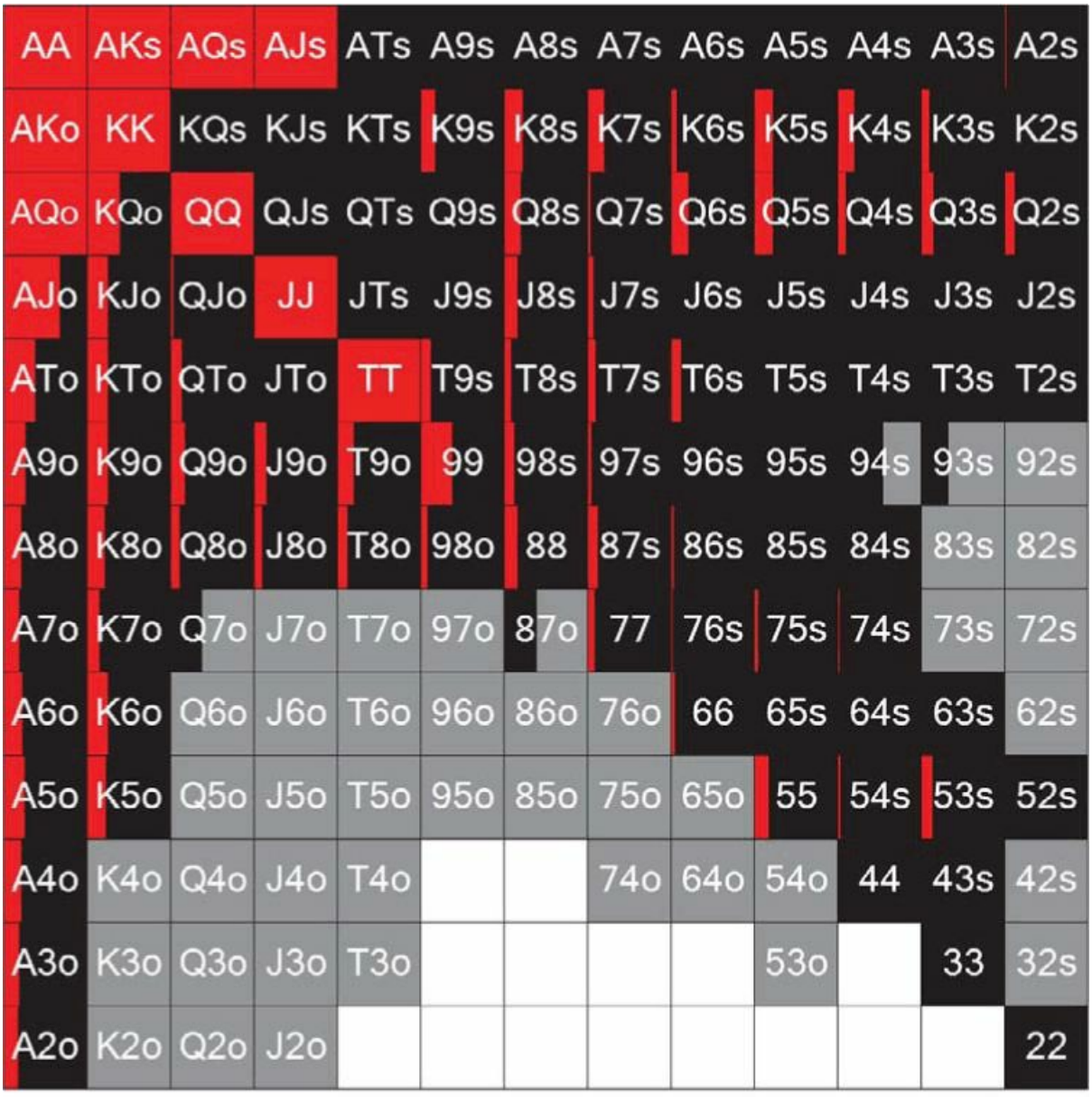
At 60bb, after limping and facing a raise, stacks are too deep to limp/shove, and so the only re-raising size is to 3.4x. The limp/reraising range is made of the best hands that are happy to stack off pre-flop and hands with good blockers and some board coverage *(Hand Ranges 106-107)*.



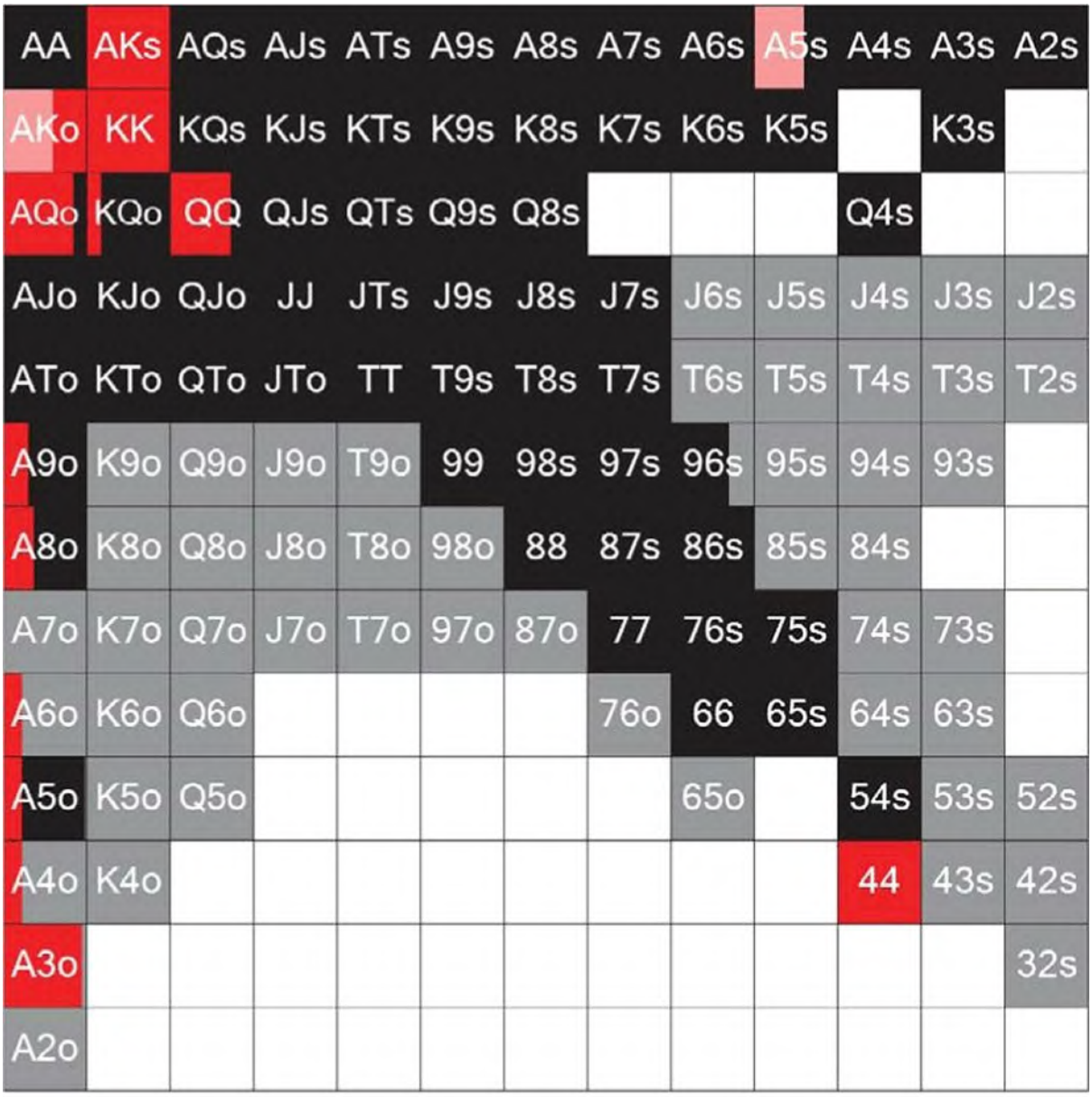
Hand Range 106: SB vs BB (60bb)
• Raise 3.5x 15.1% / • Limp 69.9% / • Fold 15%

If you raise and face a 3-bet, you are still a bit too deep to simply jam 60bb. The only hands that want to do that are AKo and A5s with a small frequency, so you are safe to simply ignore this branch of the tree and use only a 2.6x 4-bet-sizing. The hands that should be 4-bet are KK,

QQ, AK, and AQo, plus some bluffs made with blocker hands. Notice that the solver likes to slowplay AA, calls with a lot of suited hands and folds most offsuit and disconnected hands to the 3-bet *(Hand Range 108)*.



Hand Range 107:
SB vs BB 60bb (Limp vs 3.5x)
• Raise 3.4x 11.7% / • Call 47% /
• Fold 41.3%



Hand Range 108:
SB vs BB 60bb (3.5x Open vs 2.75x 3-bet)
• All-in 2% / • Raise 2.6x 8.4% /
• Call 44.5% / • Fold 45.1%

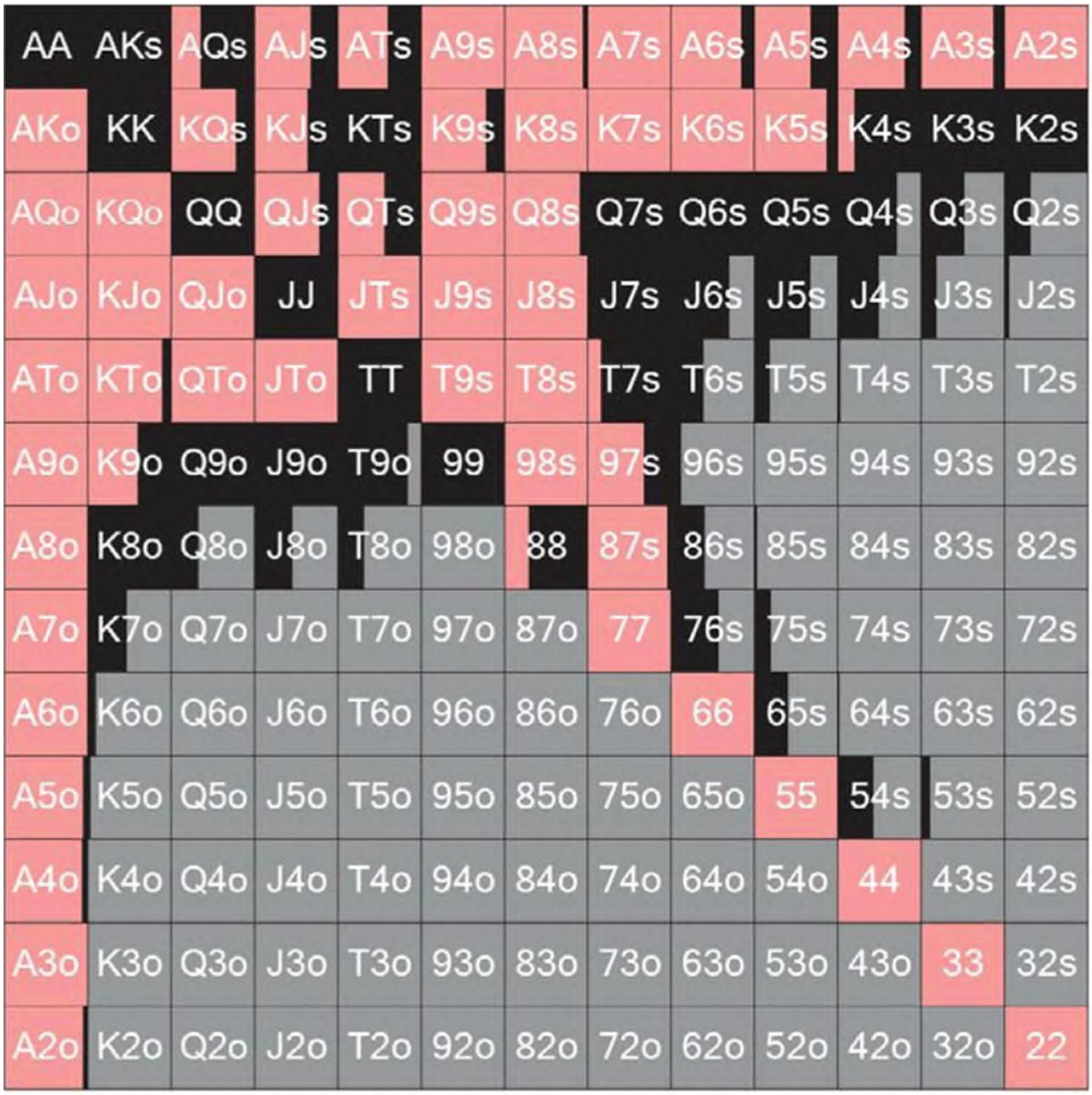
Button PFI Strategy

The BN has a very special characteristic that gives them incredible power: no other player can subsequently enter the pot and force them to play out of position. For this reason, the solver likes

developing a limping range with stack depths 10-30bb. When limping is allowed, the solver prefers limping over min-raising at stacks 10-12bb, and will play a push/limp/fold strategy with no min-raises *(Table 46)*.

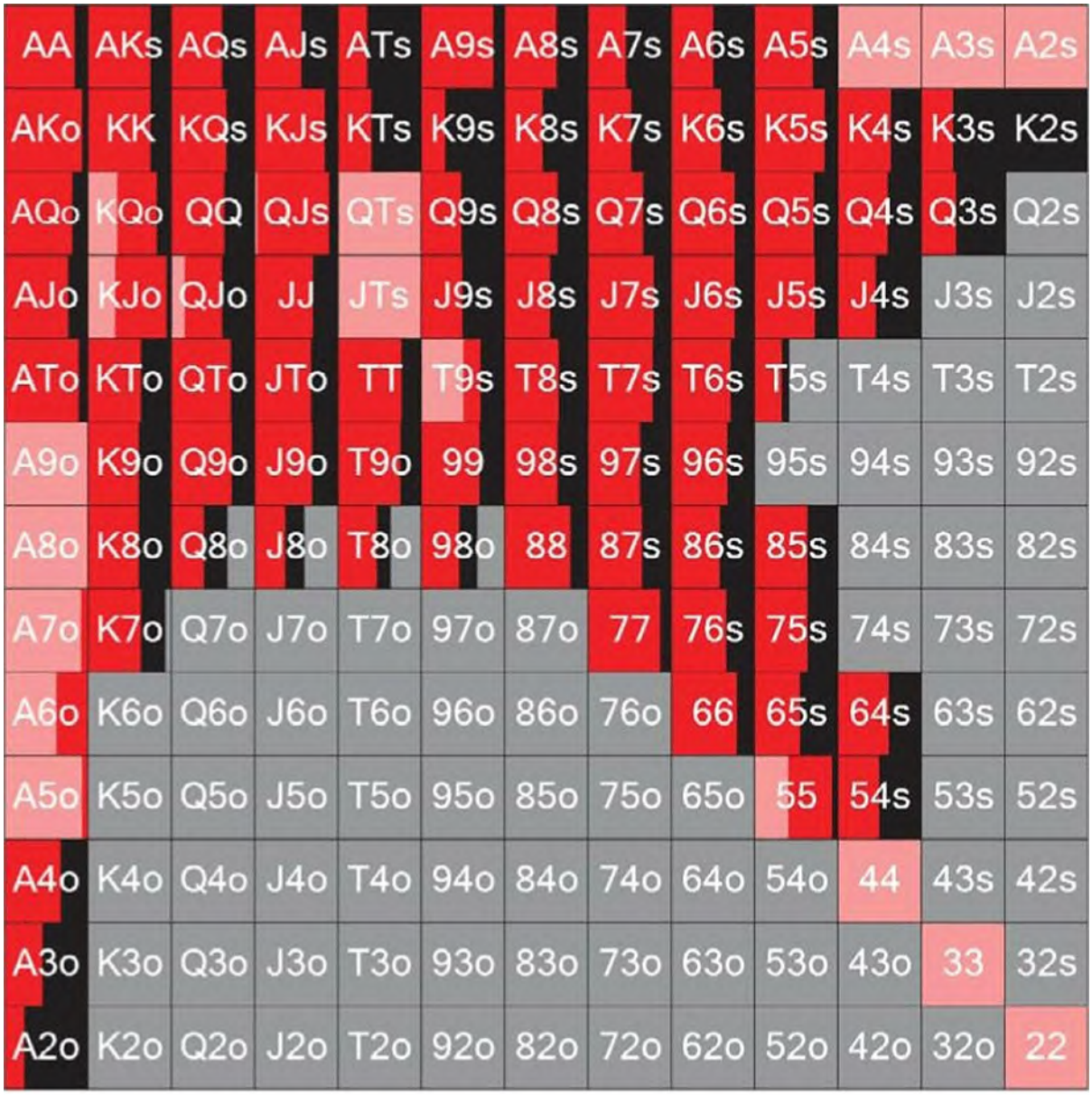
BN	Actions Frequency				Total VPIP
Stack	All-in	Raise (non-AI)	Limp	Fold	
10bb	32.60%	0.00%	8.50%	58.90%	41.10%
12bb	27.30%	0.00%	14.80%	57.90%	42.10%
15bb	21.40%	8.90%	11.40%	58.30%	41.70%
17bb	16.20%	13.50%	14.60%	55.70%	44.30%
20bb	8.00%	25.40%	12.90%	53.70%	46.30%
30bb	0.00%	43.00%	8.20%	48.80%	51.20%
				Avg VPIP	44.45%

Table 46: BN GTO Action Frequencies by Stack Depth (limping allowed)



Hand Range 109: BN 12bb (Limp)
• All-in 27.3% / • Limp 14.80% /
• Fold 57.90%

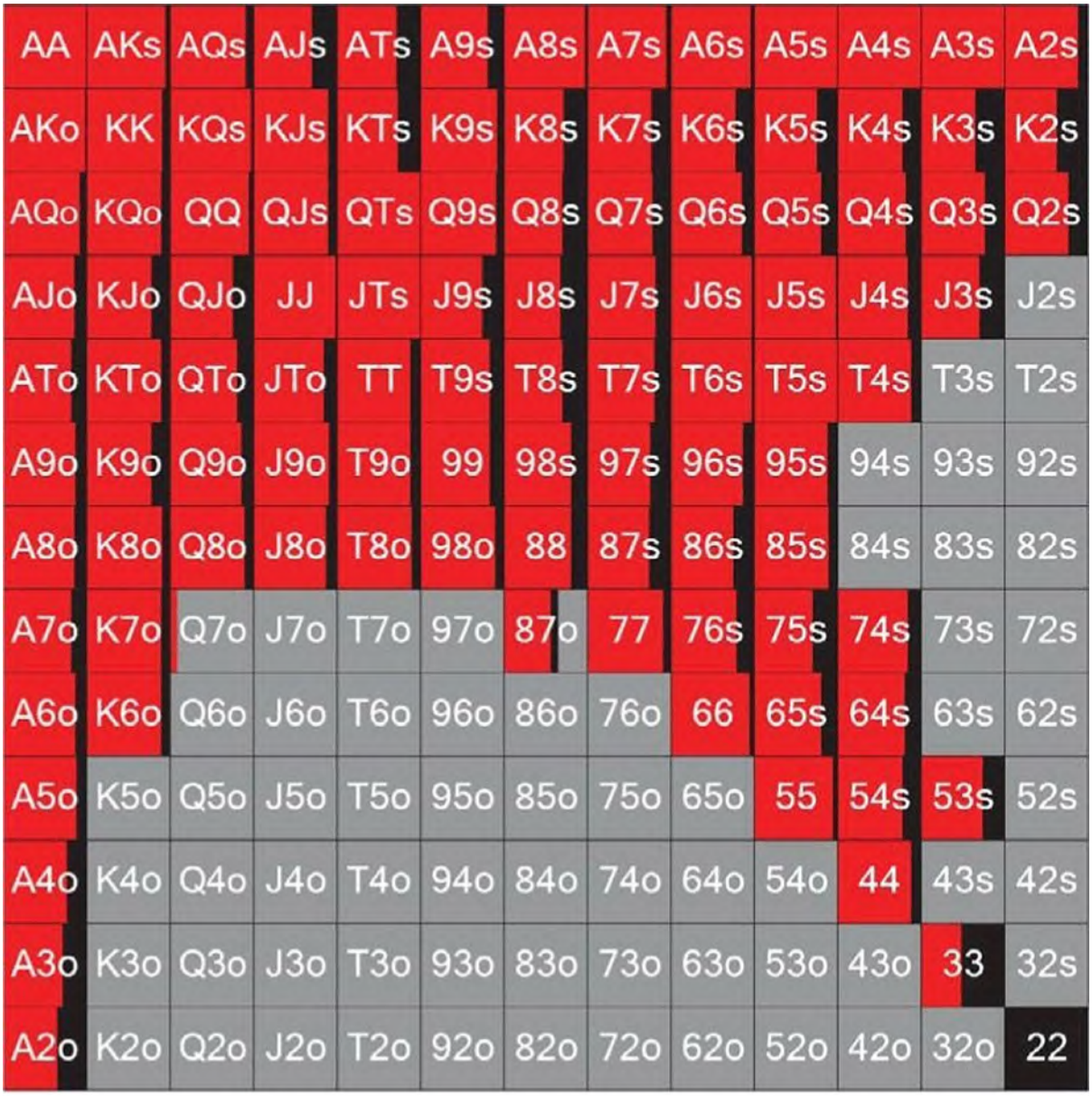
With stacks 15-30bb, min-raising becomes an important part of the BN strategy because it allows for post-flop play from in position.



Hand Range 110: BN 20bb (Limp)

• All-in 8% / • Raise 2x 25.4% /

• Limp 12.9% / • Fold 53.7%



Hand Range 111: BN 30bb (Limp)
• All-in 0% / • Raise 2x 43% /
• Limp 8.2% / • Fold 48.8%

With 30bb stacks, BN no longer open shoves, as the stacks are now too deep. Starting with 40bb stacks, the solver stops limping altogether and favors a simpler raise/fold strategy. At this stack depth rejamming all-in against opens involves a bigger risk, and this favors open raises over limping as the BN can defend very well against 3-bets by calling in position and realizing a lot of equity that would be denied when forced to fold to an all-in.

The general principles for limping are similar to those of the SB, including traps and some

weak suited hands that can benefit from seeing flops cheaply, as well as some offsuit high-mid hands that can flop good top pairs and straight draws.

The overall BN limping frequency is 11.7% and, although limping allows them to play slightly wider ranges than playing raise/fold only, there are many reasons why in modern games players rarely limp from the BN:

- ♦ Limping adds complexity to the BN strategy which makes the implementation of limps with well-balanced ranges a difficult task.
- ♦ Variance is increased as the players will be playing post-flop more often and there will be more three-way pots as limping gives a great price to the SB to come along.
- ♦ The overall EV gained by incorporating BN limps isn't as substantial as in the case of the SB because the BN doesn't have a discount on the call and post-flop play is not guaranteed to be heads-up.
- ♦ Players still over-fold their BB to BN steals, which makes BN min-raises a lot more enticing than limping.

The BN Non-limping Strategy

BN	Actions Frequency			Total VPIP
Stack	All-in	Raise (Non All-in)	Fold	
10bb	33.50%	5.40%	61.10%	38.90%
12bb	27.20%	10.60%	62.20%	37.80%
15bb	20.80%	18.50%	60.70%	39.30%
17bb	14.60%	25.60%	59.80%	40.20%
20bb	3.50%	38.40%	58.10%	41.90%
25bb	0.00%	46.30%	53.70%	46.30%
30bb	0.00%	48.60%	51.40%	48.60%
40bb	0.00%	50.90%	49.10%	50.90%
60bb	0.00%	54.40%	45.60%	54.40%
80bb	0.00%	55.60%	44.50%	55.50%
			Avg VPIP	45.38%

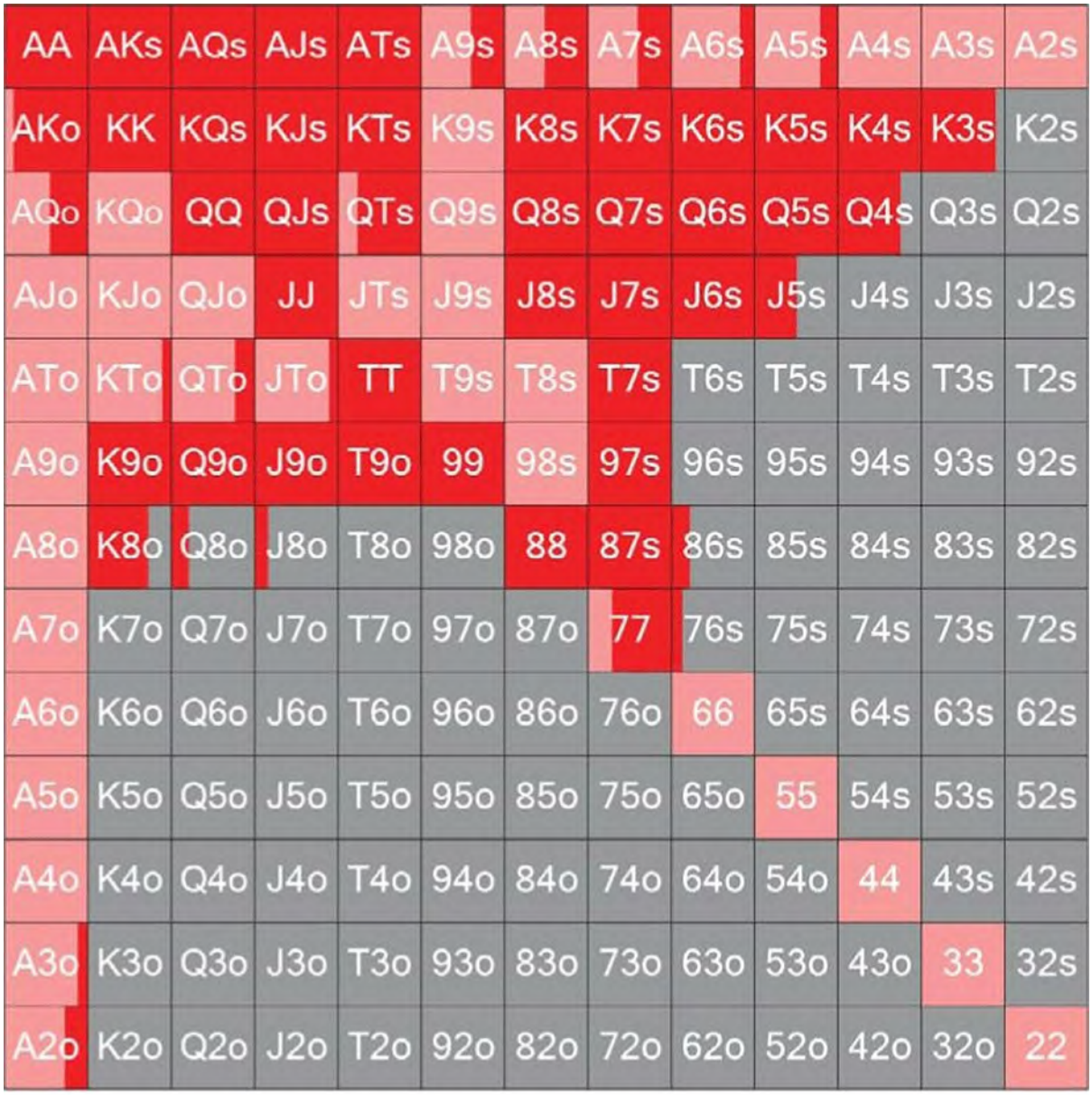
Table 47: BN GTO Action Frequencies by Stack Depth (Limping not Allowed)

In *Table 47* we can see that the deeper the stack depth, the more hands the BN gets to play, starting with 38.9% total VPIP with 10bb up to 55.5% with 80bb, for a total increase of 16.6% in raising frequency. One of the main reasons for this massive increase is that deeper stacks favor the BN's positional advantage. The best tool the blinds can use to decrease their positional disadvantage is to rejam all-in, which doesn't offer a great risk/reward ratio with stacks deeper than 40bb, so it becomes increasingly difficult for the blinds to deny equity to the BN.

Due to being guaranteed to be in position throughout the hand, the BN post-flop equity realization is the highest and it only increases further as stacks get deeper. By going all-in, the BN forsakes positional advantage and thus there is a massive reduction in the BN open pushing frequency as stacks get deeper, dropping to 3.5% at 20bb and 0% at 25bb.

BN RFI Range at 15bb

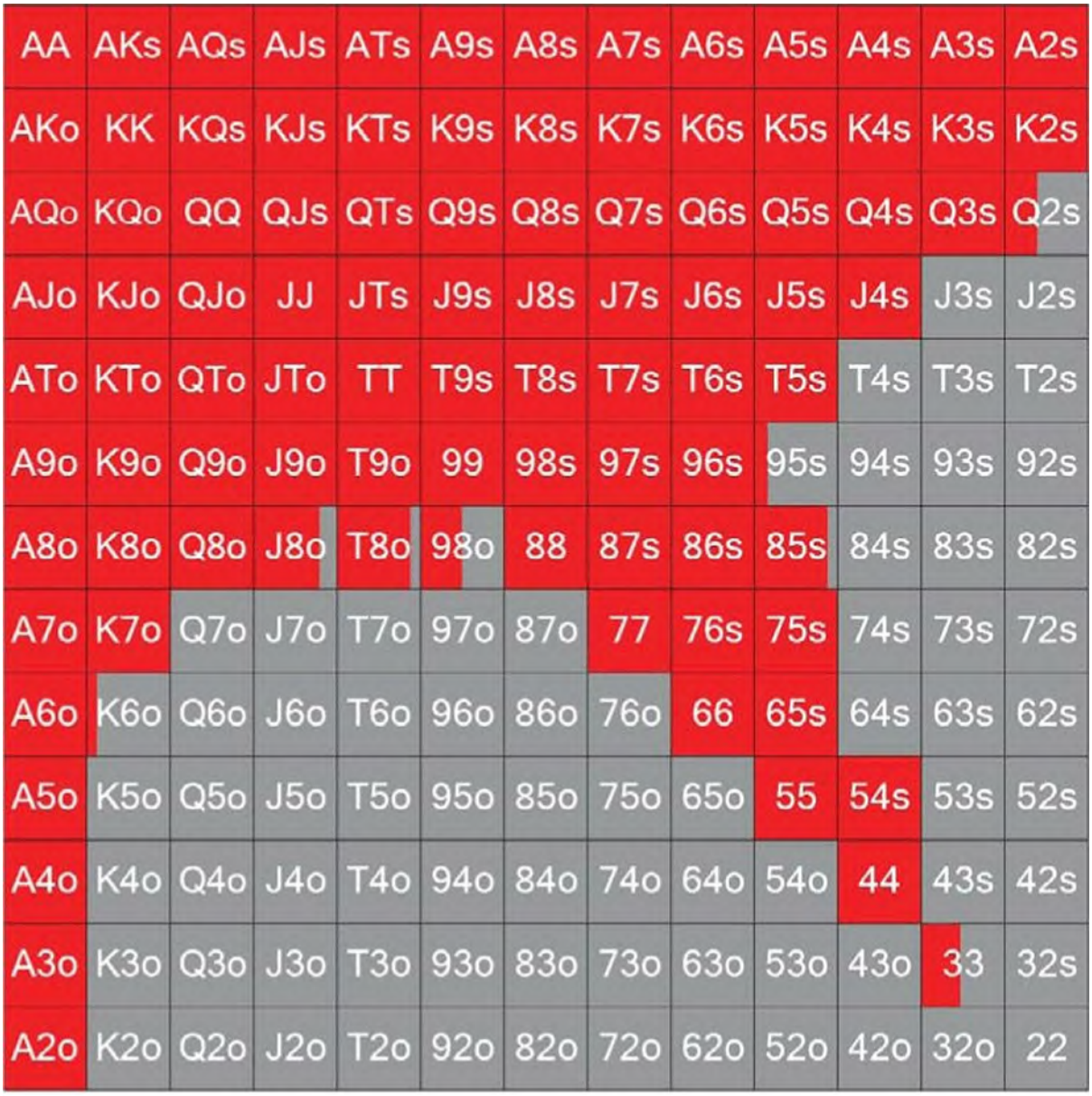
With 15bb, the BN splits their range almost 50/50 between going all-in and min-raising *(Hand Range 112)*. There is still the same pattern as before with hands that have good equity against calling ranges but don't have great post-flop playability being pushed (66-22, AJo-A2o, offsuit broadways and premium suited connectors).



Hand Range 112: BN 15bb

• All-in 20.8% / • Raise 2x 18.5% /

• Fold 60.7%



Hand Range 113: BN 25bb

• Raise 2x 46.3% / • Fold 53.7%

BN RFI Range at 25bb

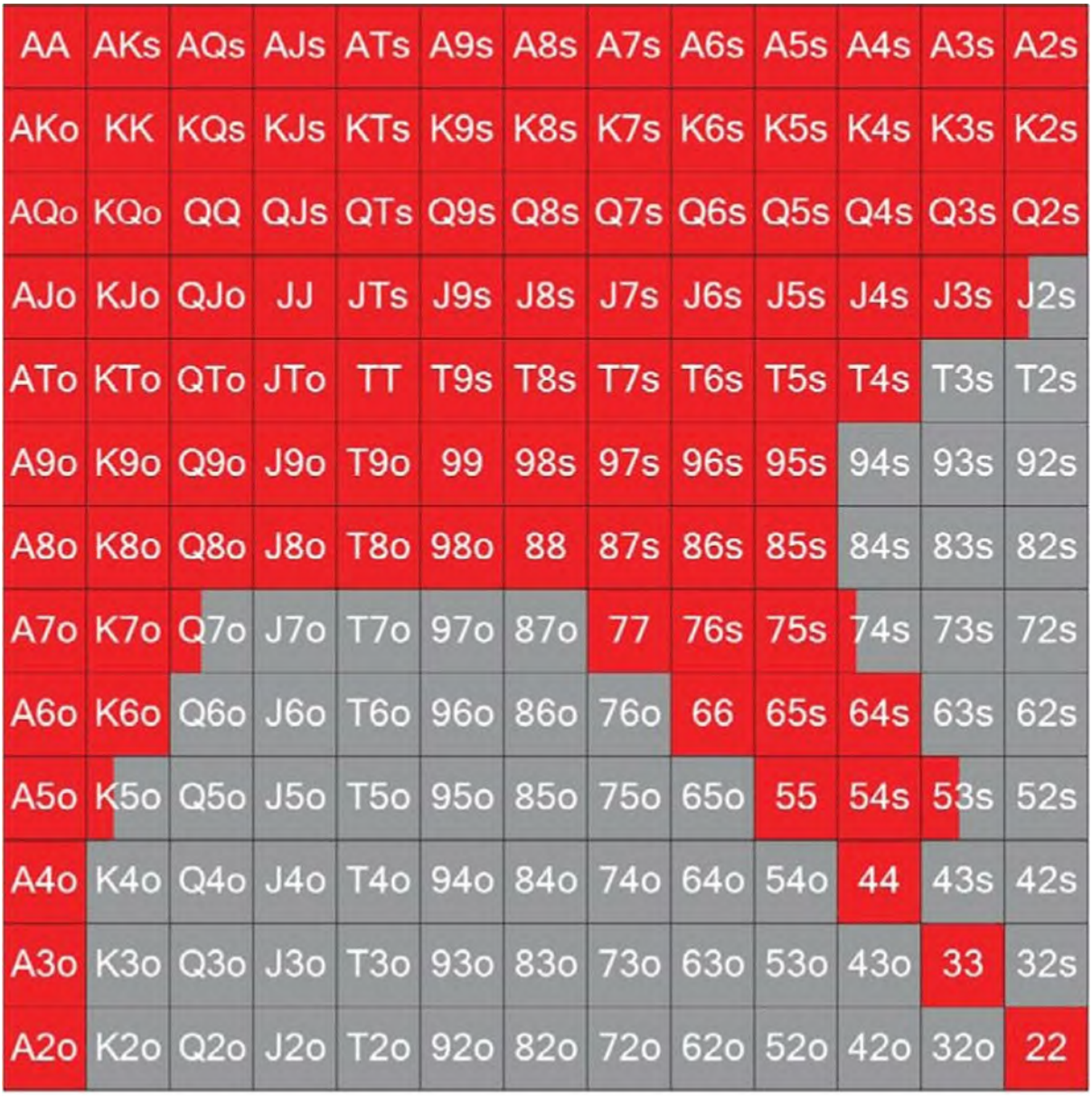
With 25bb, there is no all-in range from the BN *(Hand Range 113)*. At this stack depth having high card value and high raw equity is more important than having playability. For this reason, hands such as K7o that have a king blocker to the blinds' rejamming ranges is more valuable than having a hand with more playability such as 74s.

It might be surprising to see the BN folding pocket pairs such as 33 and 22, but these hands

don’t do well as min-raises. They have two reverse blockers (meaning they do not block playable hands) to the blinds’ rejamming ranges, so you will get re-shoved slightly more often than normal and will be forced to fold them pre-flop. If someone calls, small pairs also do not fare well. Most of the time they will be playing as an underpair and either be forced to play passively and be denied equity, or bluff and get into complicated situations where they invest way too many chips with a hand that won’t have many outs to improve. To make matters worse, implied odds are not so great at this stack depth. So, these hands should simply be folded.

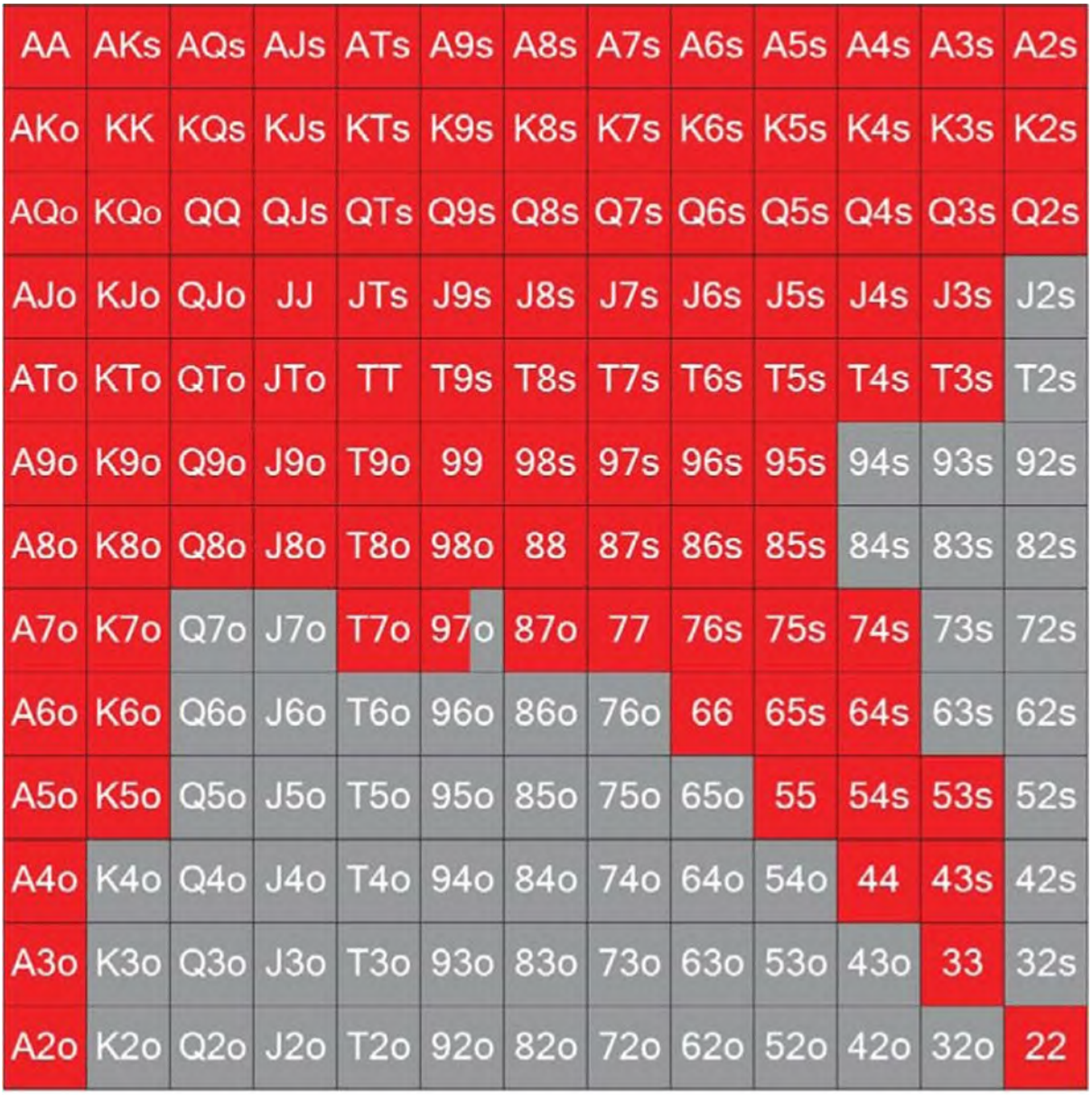
BN RFI Range at 40bb

With 40bb, the BN gets to play a wider range than with 25bb, and hands with good post-flop playability, such as suited gappers, and hands with high implied odds, such as small pocket pairs, increase in value. The 4-bet frequency is lower than at 25bb because now the SPR will be higher and allow for more post-flop play, which benefits the BN’s post-flop equity realization *(Hand Range 114)*.



Hand Range 114: BN 40bb

• Raise 2.3x 50.9% / • Fold 49.1%



Hand Range 115: BN 60bb

• Raise 2.3x 54.4% / • Fold 45.5%

BN RFI Range at 60bb

With 60bb, the BN gets to widen their opening range even more *(Hand Range 115)*. The BN 4-bet all-in frequency decreases because now the BN is deep enough to have a non-all-in 4-bet range. Additionally, the BN's positional advantage increases, so at this stack depth, BN's main defense against 3-bets is to flat-call in position at a high frequency (we will look at Defense vs 3-bet Strategies later in the book).

Cutoff PFI Strategy

There are many drawbacks to implementing limping strategies when outside the blinds and the BN because there are more players left to act who can over-limp or even raise. Any potential EV gained by implementing a limping strategy will hardly be enough to compensate for overcomplicating the overall strategy.

Furthermore, there are some limitations to what modern computers can do and adding limps for all players in a 9-max simulation exponentially increases the size of the game tree, which requires heavy use of abstractions and in turn produces inconsistent results.

For all these reasons, I decided not to include limping strategies from the cutoff onwards and will focus on analyzing the raise/fold strategy (which also is congruent with the play in modern games).

As we see in *Table 48*, the total CO VPIP increases as stacks get deeper (similarly to the BN), from 31.4% at 10bb to 37.50% at 80bb for an average of 33.69% across all positions. At 10bb and below, the CO plays a push/fold strategy and starts to incorporate min-raises at 12bb. The overall all-in frequency decreases as stacks get deeper, and sinks to 0% at 20bb.

CO	Actions Frequency			Total VPIP
Stack	All-in	Raise (Non All-in)	Fold	
10bb	31.40%	0.00%	68.60%	31.40%
12bb	23.20%	7.90%	68.90%	31.10%
15bb	13.60%	16.50%	69.80%	30.20%
17bb	6.70%	23.90%	69.50%	30.50%
20bb	0.00%	31.70%	68.30%	31.70%
25bb	0.00%	34.30%	65.70%	34.30%
30bb	0.00%	36.40%	63.60%	36.40%
40bb	0.00%	36.40%	63.60%	36.40%
60bb	0.00%	36.90%	62.60%	37.40%
80bb	0.00%	37.10%	63.30%	36.70%
			Avg VPIP	33.61%

Table 48: CO GTO Action Frequencies by Stack Depth

With 15bb, the CO all-in range contains high equity hands that are too good to raise-fold but

not good enough to raise-call, such as KTo, QJo and T9s, small and medium pocket pairs, small Axs and mid-high Axo. The min-raising range consists of the other hands that are happy to raise-call off, such as good Ax, mid-high pocket pairs, suited broadways and hands with blockers that can make good top pairs that can easily be raise-folded when facing a rejam *(Hand Range 116)*.

Hand Range 116: CO 15bb
• All-in 13.6% / • Raise 2x 16.5% /
• Fold 69.8%

Hand Range 117: CO 25bb

• Raise 2x 34.3% / • Fold 65.7%

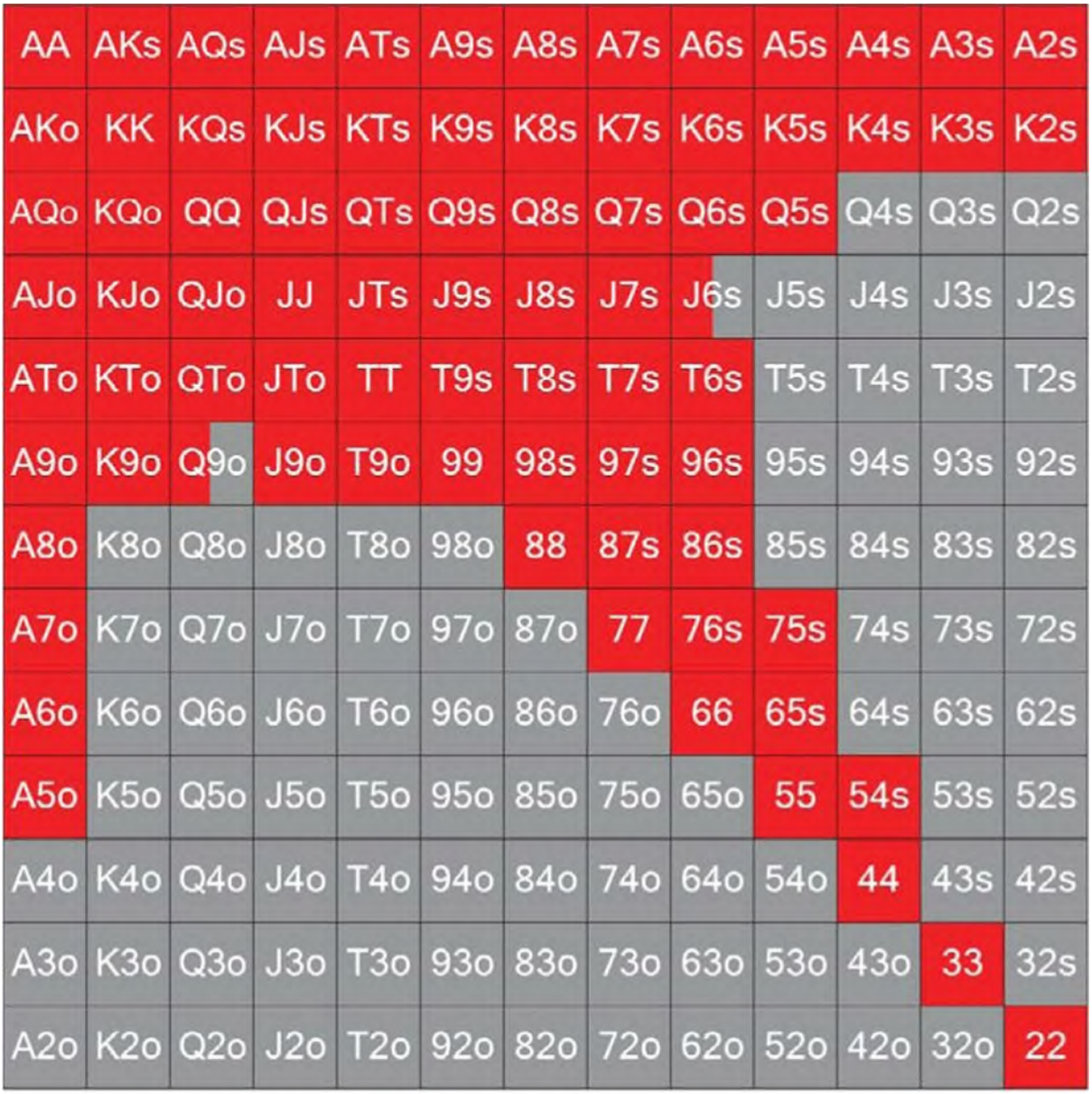
With 25bb, there is no all-in range *(Hand Range 117)*. Again, this stack depth is a bit too awkward to play 33 and 22 because you are too deep to open jam and too shallow to have the correct implied odds. Therefore folding is the best play when first in from all positions (except the SB).

With 40bb, the CO can open a slightly wider range than at 25bb, starting to incorporate some hands that play well post-flop at deeper stacks such as 33 and 22, plus a few extra suited hands such as K2s, Q4s, T6s and 96s *(Hand Range 118)*. At 60bb the CO plays a very similar range

(Hand Range 119).

Hand Range 118: CO 40bb

• Raise 2.3x 36.4% / • Fold 63.6%



Hand Range 119: CO 60bb

• Raise 2.3x 37.1% / • Fold 62.3%

Hijack PFI Strategy

From middle position, ranges must become tighter compared to late position due to there being more players left to act and Hero being forced to play OOP more often.

At deeper stack depths, the positional disadvantage MP and EP have becomes more relevant and the threat of having to play OOP hinders their ability to realize equity post-flop effectively

enough to expand their ranges as stacks get deeper. For this reason, from MP and EP, there is no direct correlation between stack depth and VPIP, and instead we see the VPIP frequency peak at 25-30bb and then either stagnate or decrease.

As we see in *Table 49*, the overall HJ VPIP frequency is 26.89%. At 10bb and below, you should only play push/fold. At 12bb, develop a minraising range, which becomes dominant at 15bb *(Hand Range 120)*. At 17bb, the all-in option starts to disappear, with raise/fold becoming the only viable strategy at 20bb and deeper.

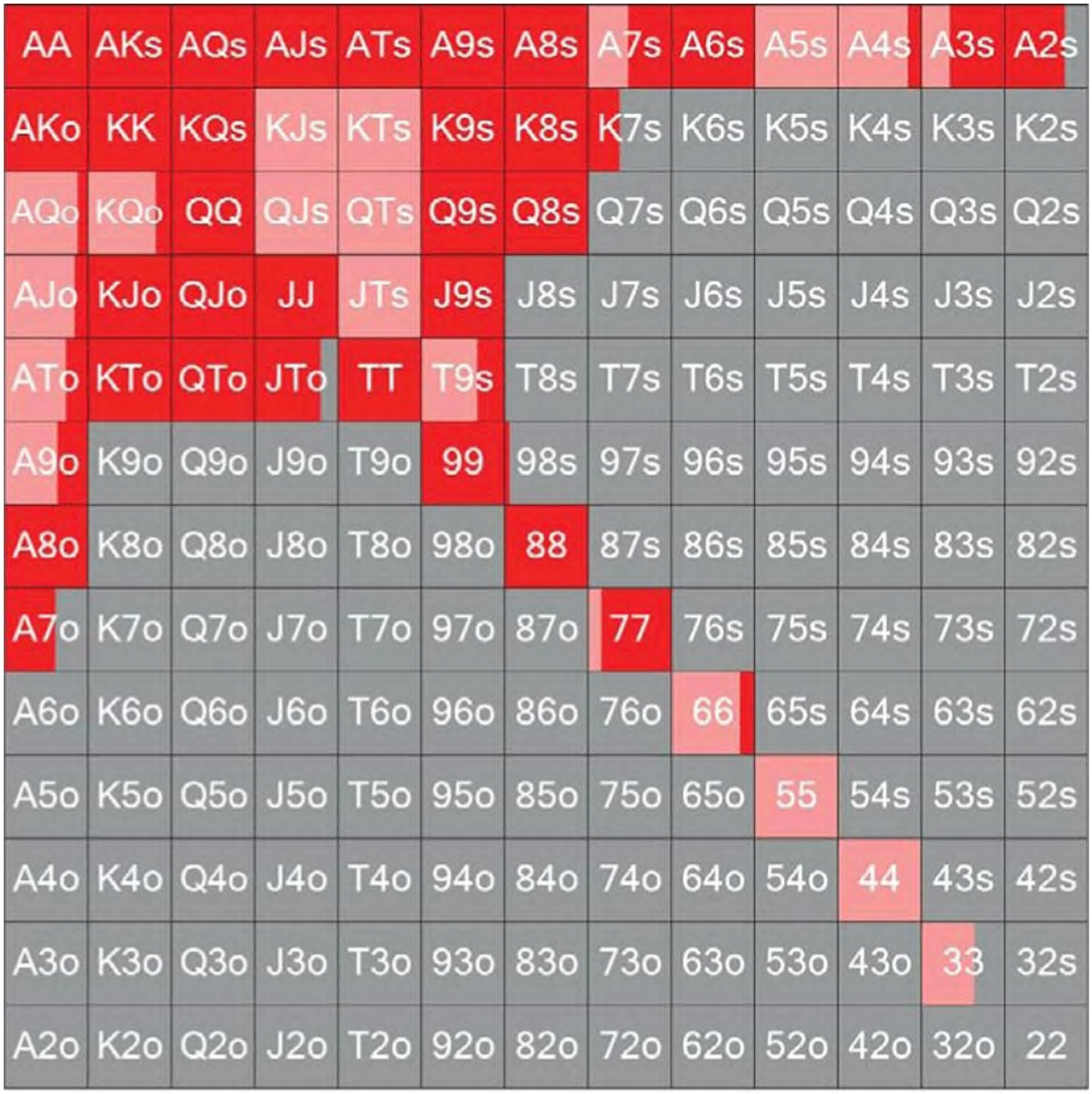
With 25bb, there is no all-in range *(Hand Range 121)*. The minraising range focuses on high card value with hands that can make strong top pairs or good flush draws.

HJ	Actions Frequency			Total VPIP
Stack	All-in	Raise (Non All-in)	Fold	
10bb	27.70%	0.00%	72.30%	27.70%
12bb	17.00%	7.80%	75.20%	24.80%
15bb	7.70%	16.10%	76.20%	23.80%
17bb	2.40%	22.10%	75.50%	24.50%
20bb	0.00%	26.00%	74.00%	26.00%
25bb	0.00%	27.80%	72.20%	27.80%
30bb	0.00%	29.30%	70.70%	29.30%
40bb	0.00%	28.60%	71.40%	28.60%
60bb	0.00%	28.20%	71.90%	28.10%
80bb	0.00%	28.00%	71.80%	28.20%
			Avg VPIP	26.88%

Table 49: Hijack GTO Action Frequencies by Stack Depth

With 40bb, a few more hands are added that play better with slightly deeper stacks such as 33, 96s and 54s, but the overall HJ range shape doesn't change too much from 25bb to 40bb *(Hand Range 122)*.

With 60bb, the HJ opens at roughly the same frequency as with 40bb, but there is a small change in the range shape, dropping some of the weaker high-low type hands such as K3s, A7o, and Q6s, and adding more hands that have the possibility of flopping premium hands such as 22 and small suited connectors *(Hand Range 123)*.



Hand Range 120: HJ 15bb

• All-in 7.7% / • Raise 2x 16.1% /

• Fold 76.2%

Hand Range 121: HJ 25bb

• Raise 2x 27.8% / • Fold 72.2%

Hand Range 122: HJ 40bb

• Raise 2.3x 28.6% / • Fold 71.4%

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

Hand Range 123: HJ 60bb

• Raise 2.3x 28% / • Fold 71.7%

Lojack PFI Strategy

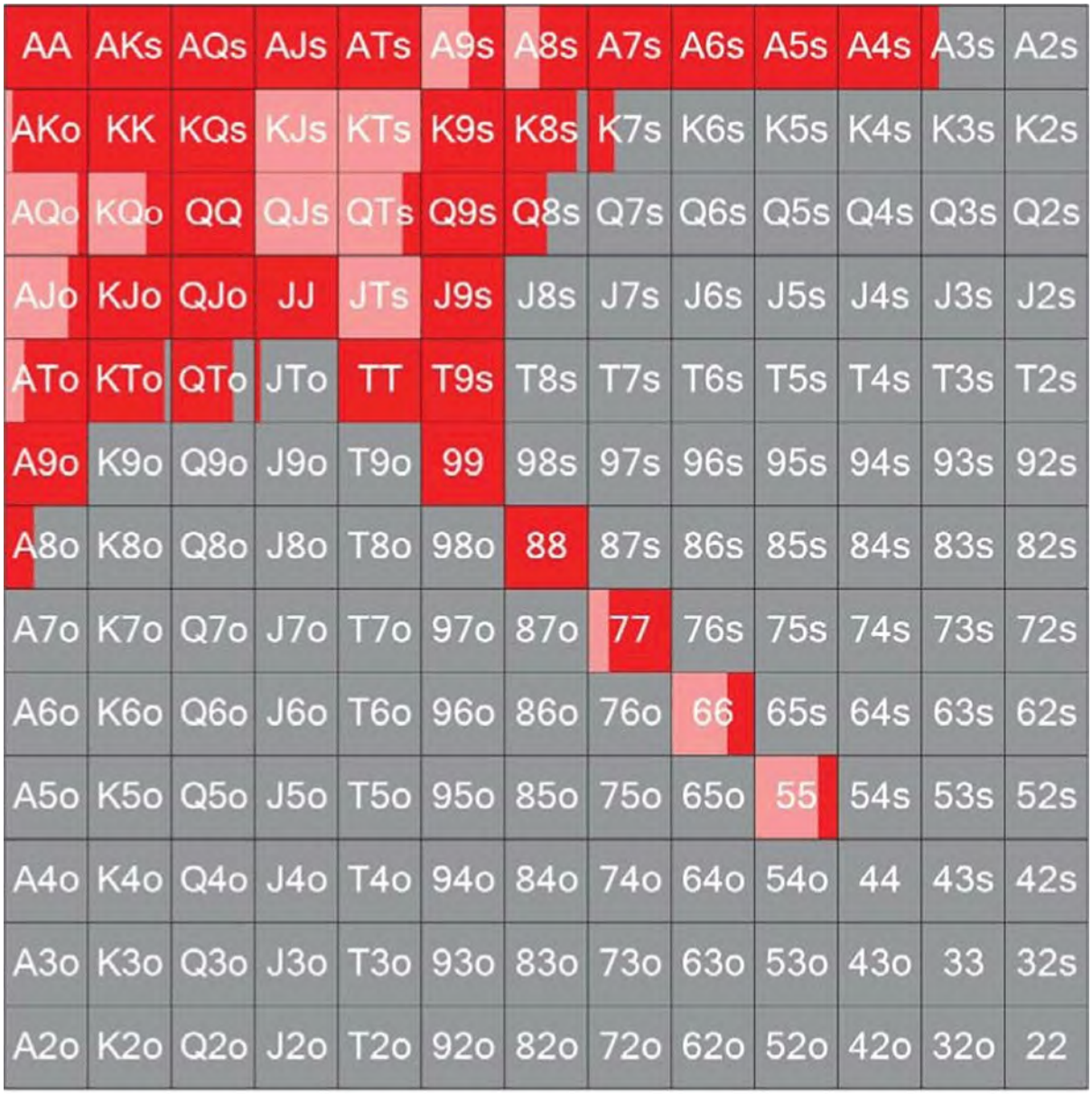
The LJ play is similar to the HJ, but the overall range shrinks to 22.54% due to the slight positional disadvantage. Another interesting difference is that at this position there is now raise-folding range at 10bb stack depths. There are still open shoves at 15bb, but at 17bb, now due to being too deep to open jam, there are no shoves.

LJ	Actions Frequency			Total VPIP
Stack	All-in	Raise (Non All-in)	Fold	
10bb	20.30%	2.30%	77.40%	22.60%
12bb	13.70%	7.80%	78.50%	21.50%
15bb	4.90%	15.30%	79.80%	20.20%
17bb	0.00%	21.00%	79.00%	21.00%
20bb	0.00%	22.00%	78.00%	22.00%
25bb	0.00%	24.10%	75.90%	24.10%
30bb	0.00%	24.80%	75.20%	24.80%
40bb	0.00%	23.60%	76.40%	23.60%
60bb	0.00%	23.00%	77.30%	22.70%
80bb	0.00%	22.50%	77.60%	22.40%
			Avg VPIP	22.49%

Table 50: Lojack GTO Action Frequencies by Stack Depth

In *Table 50* we see that, with 15bb, the LJ likes to have a small open shoving range made of hands that really benefit from getting all-in pre-flop and realizing their 100% of their equity, such as 77-55, AQo, AJo, A9s, A8s and JTs+ *(Hand Range 124)*.

With 25bb, there is a high increase in VPIP compared to 15bb. At this stack depth hands that can flop good top pairs, straight draws and flush draws, such as J8s, T8s and 98s, start opening, but 44 and 33 are folded due to being too deep to open jam them *(Hand Range 125)*.



Hand Range 124: LJ 15bb

• All-in 4.9% / • Raise 2x 15.3% /

• Fold 79.8%

Hand Range 125: LJ 25bb

• Raise 2x 24.1% / • Fold 75.9%

Hand Range 126: LJ 40bb

• Raise 2.3x 23.6% / • Fold 76.4%

Hand Range 127: LJ 60bb

• Raise 2.3x 23% / • Fold 77.2%

With 60bb, the LJ opens slightly tighter than with 40bb, lowering the frequency of the marginal hands such as suited broadways, small pocket pairs and low suited connectors *(Hand Range 127)*.

With 40bb, the range shape doesn't change too much although there is a shift from high card value to connectedness *(Hand Range 126)*.

UTG+2 PFI Strategy

In early position, the average VPIP drops below the 20% mark because now it is necessary to go through at least six opponents. Many speculative hands decrease in value as the likelihood of being 3-bet or having to play post-flop OOP increases with the number of players left to act.

UTG+2	Actions Frequency			Total VPIP
Stack	All-in	Raise (Non All-in)	Fold	
10bb	16.60%	5.90%	80.50%	19.50%
12bb	9.70%	8.00%	82.20%	17.80%
15bb	2.20%	15.30%	82.60%	17.40%
17bb	0.00%	18.00%	82.00%	18.00%
20bb	0.00%	19.30%	80.70%	19.30%
25bb	0.00%	21.30%	78.70%	21.30%
30bb	0.00%	21.10%	78.90%	21.10%
40bb	0.00%	20.60%	79.40%	20.60%
60bb	0.00%	19.00%	81.20%	18.80%
80bb	0.00%	18.80%	77.50%	22.50%
			Avg VPIP	19.63%

Table 51: UTG+2 GTO Action Frequencies by Stack Depth

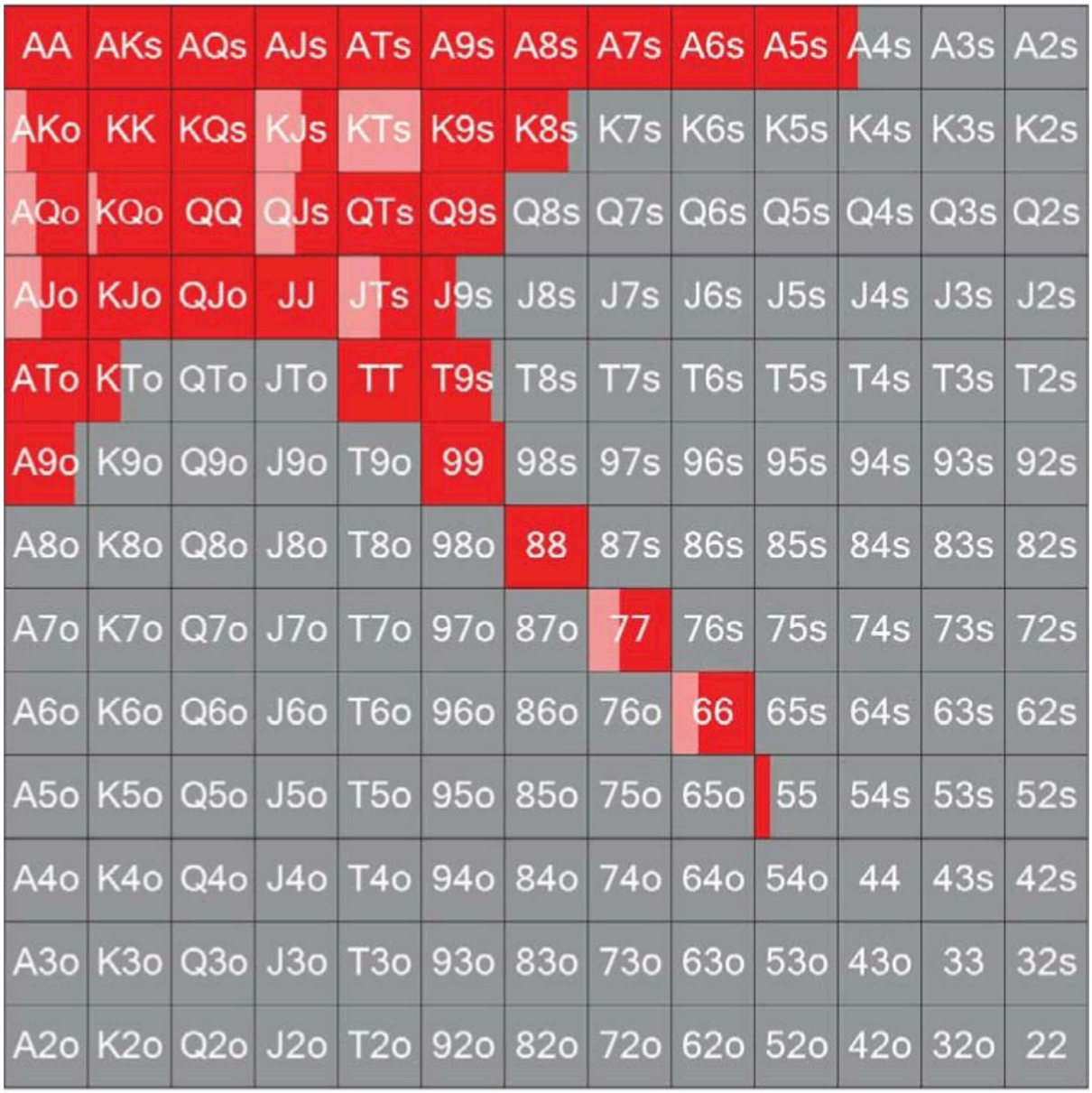
Table 51 demonstrates that UTG+2 VPIP frequency peaks at 21% between 25-30bb but averages 19.63% across the board. With so many players left to act you should be hesitant to open jam for too many chips because of the increased chance of someone waking up with a premium holding. For this reason, there is an overall drop in open jam frequencies, and this trend will continue as your position worsens.

With 15bb, there is a tiny all-in range of 2.2% but, in practice, it is better to play a raise/fold strategy because all hands that are jammed are indifferent to a min-raise *(Hand Range 128)*. At 17bb the all-in range disappears completely.

With 25bb, the baby Ax hands and the strongest suited connectors can be raised *(Hand Range 129)*.

With 40bb, offsuit broadways start to lose value and small suited connectors start to become more relevant *(Hand Range 130)*.

With 60bb, small suited connectors such as 87s-65s and weak suited high-low card hands such as K7s, K6s, Q8s and J8s begin to struggle. The range shifts focus towards stronger hands that will be dominated less often, adding small pairs such as 44 and 33 that can flop premium hands and are easy to play post-flop *(Hand Range 131)*.



Hand Range 128: UTG+2 15bb
• All-in 2.2% / • Raise 2x 15.3% /
• Fold 82.6%

Hand Range 129: UTG+2 25bb

• Raise 2x 21.3% / • Fold 78.7%

Hand Range 130: UTG+2 40bb

• Raise 2.3x 20.6% / • Fold 79.4%

Hand Range 131: UTG+2 60bb
• Raise 2.3x 19% / • Fold 80.9%

UTG+1 PFI Strategy

In this position the average VPIP is 16.75% and peaks at 18.60% with 25bb. At 12bb, your opening range is played almost 50/50 between a push and a min-raise.

UTG+1	Actions Frequency			Total VPIP
Stack	All-in	Raise (Non All-in)	Fold	
10bb	12.80%	4.10%	83.00%	17.00%
12bb	7.90%	7.70%	84.30%	15.70%
15bb	0.50%	15.10%	84.40%	15.60%
17bb	0.00%	15.80%	84.20%	15.80%
20bb	0.00%	17.40%	82.60%	17.40%
25bb	0.00%	18.60%	81.40%	18.60%
30bb	0.00%	16.30%	83.70%	16.30%
40bb	0.00%	17.60%	82.40%	17.60%
60bb	0.00%	16.50%	83.20%	16.80%
80bb	0.00%	16.60%	83.50%	16.50%
			Avg VPIP	16.73%

Table 52: UTG+1 GTO Action Frequencies by Stack Depth

Play for UTG+1 is quite straightforward.

At 15bb, stacks are too deep to jam, so only a raise/fold strategy is used *(Hand Range 132)*.

At 25bb, A4s, A3s and the strongest suited connectors are added *(Hand Range 133)*.

At 40bb, the range shrinks somewhat compared to 25bb, focusing towards hands with good playability that can flop the nuts or nut draws. The weaker offsuit broadways start to decrease in value as they will struggle to call 3-bets and making top pair isn't as valuable as it was with shallower stacks *(Hand Range 134)*.

At 60bb, the range is again tighter than compared to 40bb. Offsuit broadways become almost unplayable, as do suited connectors. The range focus shifts towards raw high equity and good blocker type hands *(Hand Range 135)*.

Hand Range 132: UTG+1 15bb

• All-in 0.5% / • Raise 2x 15.1% /

• Fold 84.3%

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

Hand Range 133: UTG+1 25bb

• Raise 2x 18.6% / • Fold 81.4%

Hand Range 134: UTG+1 40bb

• Raise 2x 17.6% / • Fold 82.4%

Hand Range 135: UTG+1 60bb
• Raise 2x 16.5% / • Fold 83%

UTG PFI Strategy

Unsurprisingly, UTG has the tightest range of all positions, with an average of 15.42% VPIP across all stack depths. As the stacks get deeper, there is not much of an increase in VPIP. Instead, the type of hands that are played differs. With shallower stacks, the focus is on high equity hands and good blockers and with deeper stacks, the focus is on hands that can make the

nuts or nut draws.

UTG	Actions Frequency			Total VPIP
Stack	All-in	Raise (Non All-in)	Fold	
10bb	11.00%	4.40%	84.60%	15.40%
12bb	6.20%	7.50%	86.20%	13.80%
15bb	0.00%	14.10%	85.90%	14.10%
17bb	0.00%	14.80%	85.20%	14.80%
20bb	0.00%	16.00%	84.00%	16.00%
25bb	0.00%	16.80%	83.20%	16.80%
30bb	0.00%	16.30%	83.70%	16.30%
40bb	0.00%	15.80%	84.20%	15.80%
60bb	0.00%	15.20%	84.90%	15.10%
80bb	0.00%	14.10%	85.90%	14.10%
			Avg VPIP	15.22%

Table 53: UTG GTO Action Frequencies by Stack Depth

Table 53 shows that the UTG average VPIP is 15.22%. With 10-14bb UTG plays a mixed strategy that involves min-raising and open jamming. With more than 15bb, the all-in range disappears and the strategy becomes raise/fold only. The VPIP frequency peaks at 20-30bb stacks and then starts to decrease again with deeper stacks. As stacks get deeper, there is a decrease in the RFI frequency for offsuit broadways and an increase in suited connectors and small pairs, although the frequency is really small as their main purpose is to provide better board coverage *(Hand Ranges 136-139)*.

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

Hand Range 136: UTG 15bb

• Raise 2x 14.1% / • Fold 85.9%

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

Hand Range 137: UTG 25bb

• Raise 2x 16.8% / • Fold 83.2%

Hand Range 138: UTG 40bb

• Raise 2x 15.8% / • Fold 84.2%

Hand Range 139: UTG 60bb

• Raise 2x 15.2% / • Fold 84.2%

08

MTT EQUILIBRIUM

STRATEGIES: DEFENSE

Defending vs Open Raises

Defending correctly against open raises is vital in all poker variants and even more so in tournament poker with all the possible stack depths and positions involved.

This chapter presents a comprehensive guide to playing from the most important positions (BB, SB, BN, MP and EP) after someone else has already entered the pot with a raise. We will first discuss some general considerations and then examine the specific strategy recommended by solvers for all positions at stacks depths of 15bb, 25bb, 40bb and 60bb.

Theoretical Considerations

The following are important concepts to bear in mind when deciding how to meet an open raise.

Average Action Frequencies vs Open Raise

The following two tables give an idea of the frequency with which you should be responding to open raises based on your position *(Table 54)* and that of the Villain *(Table 55)*. Note that the blind vs blind stats are omitted here as they will be displayed in the Blind vs Blind section.

Position	Avg All-in	Avg 3-bet	Avg Call	Avg Fold	Total 3-bet
BB	4.70%	5.85%	60.30%	29.14%	10.55%
SB	6.15%	6.03%	10.64%	76.78%	12.19%
BN	3.42%	4.37%	12.94%	79.28%	7.78%
CO	3.24%	4.02%	8.69%	84.05%	7.26%
HJ	2.69%	4.01%	6.41%	86.89%	6.69%
LJ	2.31%	3.79%	5.02%	84.72%	6.10%
UTG+2	1.96%	3.88%	3.50%	90.69%	5.84%
UTG+1	1.80%	3.90%	2.63%	91.65%	5.70%
Total	3.89%	4.82%	19.08%	71.77%	8.70%

Table 54: Average Response to an Open Raise Based on Position

Versus Position	Avg All-in	Avg 3bet	Avg Call	Avg Fold	Total 3bet
BN	9.64%	9.49%	35.34%	45.51%	19.13%
CO	6.78%	6.72%	28.27%	58.23%	13.50%
HJ	5.14%	5.32%	23.16%	66.38%	10.46%
LJ	3.96%	4.81%	19.90%	71.34%	8.77%
UTG+2	3.21%	4.38%	16.82%	73.43%	7.59%
UTG+1	2.66%	3.98%	15.33%	78.05%	6.64%
UTG	2.27%	3.75%	14.02%	79.66%	6.02%
Total	3.89%	4.82%	19.08%	71.77%	8.70%

Table 55: Average Response to an Open Raise Based on Villain Position

Facing an Open Shove

When facing an open shove there are two possibilities; either the player going all-in will have the bigger of the two stacks or they won't. If the total amount you have to call is more than 1/3 of your stack, you should rejam all-in over the top, except in some very heavy ICM/Bubble situations where you can still call and sometimes fold if another player decides to also go all-in.

If the call is for less than 1/3 of your stack you should call with all of your continuing range or min-re-raise if the all-in is small and you want to make sure you get heads-up. There is no need to risk everything if there are players remaining with deep stacks. For example, let's assume UTG jams for 6bb and everyone else has 35bb. If you are in the cutoff, you can simply call the 6bb and expect the other players to play straightforwardly, only rejamming with their best hands, expecting you to call off with most of your range. Of course, you will have some junk in your range, but you will also have all the premium hands.

> *The range of hands you can call off depends on the pot odds you are getting, your position, and the position of the player who is all-in. The earlier their position and the deeper their stack depth, the tighter your calling range has to be.*

The best way to get proficient at short stack play is to practice with different stack depth set-ups in a push/fold app. Take note of what players are supposed to shove with, compare that to your experience of what they do actually shove with, and then examine the ranges you are supposed to call with from various positions. You may find that some players shove way too tightly and others shove too loosely, resulting in you having to adjust your calling ranges.

Overcalling

When considering entering the pot after a raise and a call, play a tighter range compared to when there is only a raise and no calls. This seems counter-intuitive because now there is more dead money in the pot and the caller is announcing that they probably don't have a premium hand (if so they would have 3-bet). However, even after removing the top of the caller's range, their range is still quite strong and should have plenty of hands that can withstand a 3-bet. For this reason, 3-betting with too many marginal hands will be detrimental if you will have to play post-flop against a strong and well-balanced range.

Since you are forced to play tighter than usual, your range more often than not will do better by 3-betting instead of cold-calling. Still, there are some hands that retain their equity quite well even in multi-way pots and also have the ability to dominate some of the opponents' ranges, thus overcalling may still be an option.

> *Some hands that play well in multi-way pots are suited Ax, suited connectors, suited broadways and medium and small pocket pairs. Offsuit high and low card hands, such as offsuit gappers, K5o and Q7o, are extremely bad holdings to play multi-way as they will usually be dominated and will struggle to realize equity, especially when OOP.*

Big Blind Versus Small Blind

Playing the BB vs the SB is a very different situation to those when the opener has position post-flop. BvB (blind vs blind) is the only situation where the BB is in position throughout the entire hand. For this reason, the BB's equity realization is a lot higher compared to when they are defending vs any other position. This allows the BB to defend extremely effectively vs the SB's open raises and play more hands profitably than would be possible if they were OOP. You will find that when SB raises, it is often to a large (or perhaps all-in) size to give BB worse odds to defend. When facing a raise, BB has the options to fold, call, or re-raise.

Since the BB can easily defend against raises, SB will often limp, resulting in BB having the options to check behind and see a flop in position or raise and re-open the betting.

This section will analyze in detail the BB's equilibrium strategies for all of these situations.

BB vs SB Push

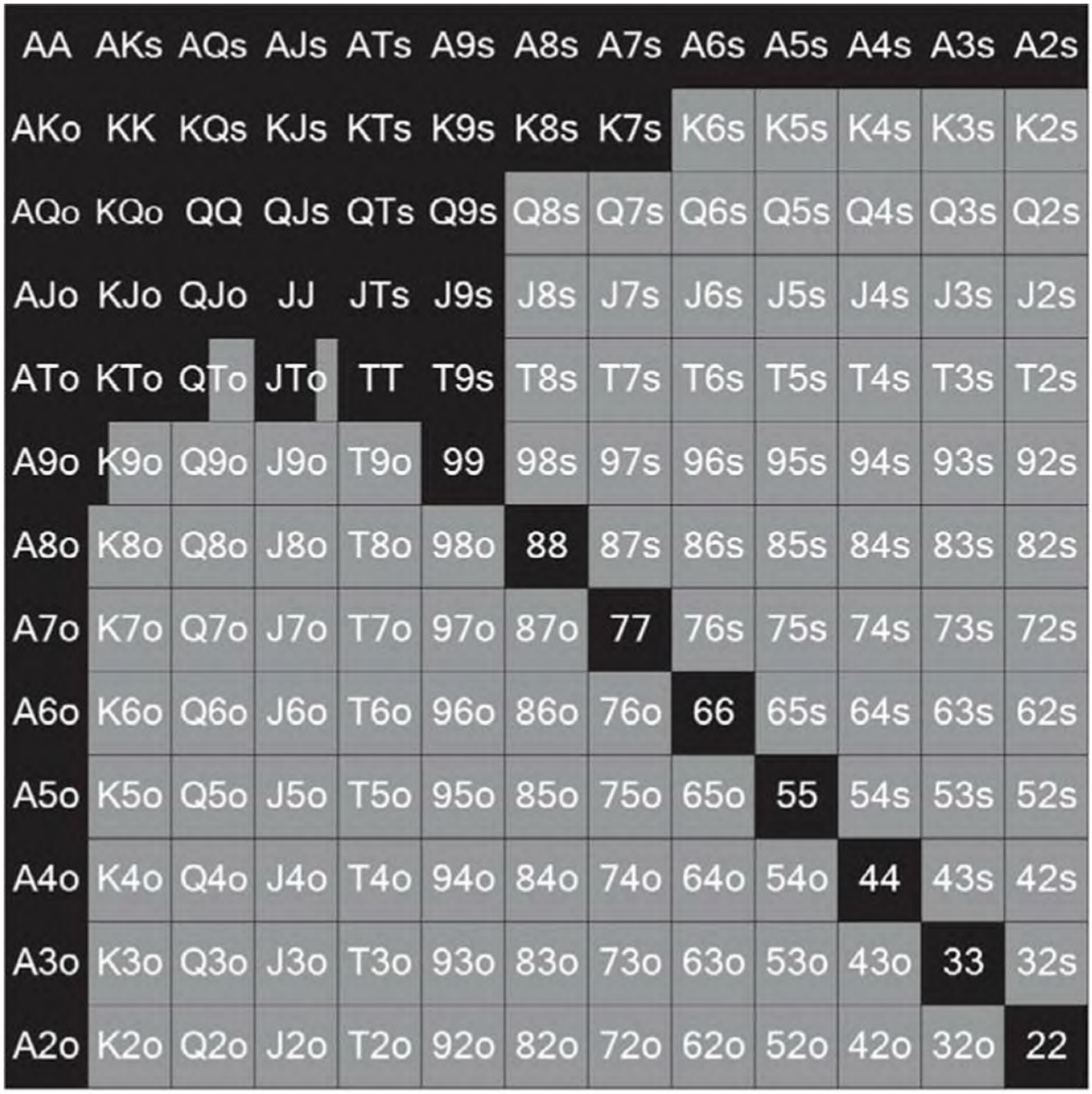
BB vs SB Push	Actions Frequency	
Stack	Call	Fold
10bb	44.50%	55.50%
12bb	38.40%	61.60%
15bb	28.90%	71.10%
17bb	27.60%	72.40%
20bb	23.40%	76.60%
25bb	17.80%	82.20%

Table 56: BB vs SB Push Action Frequencies

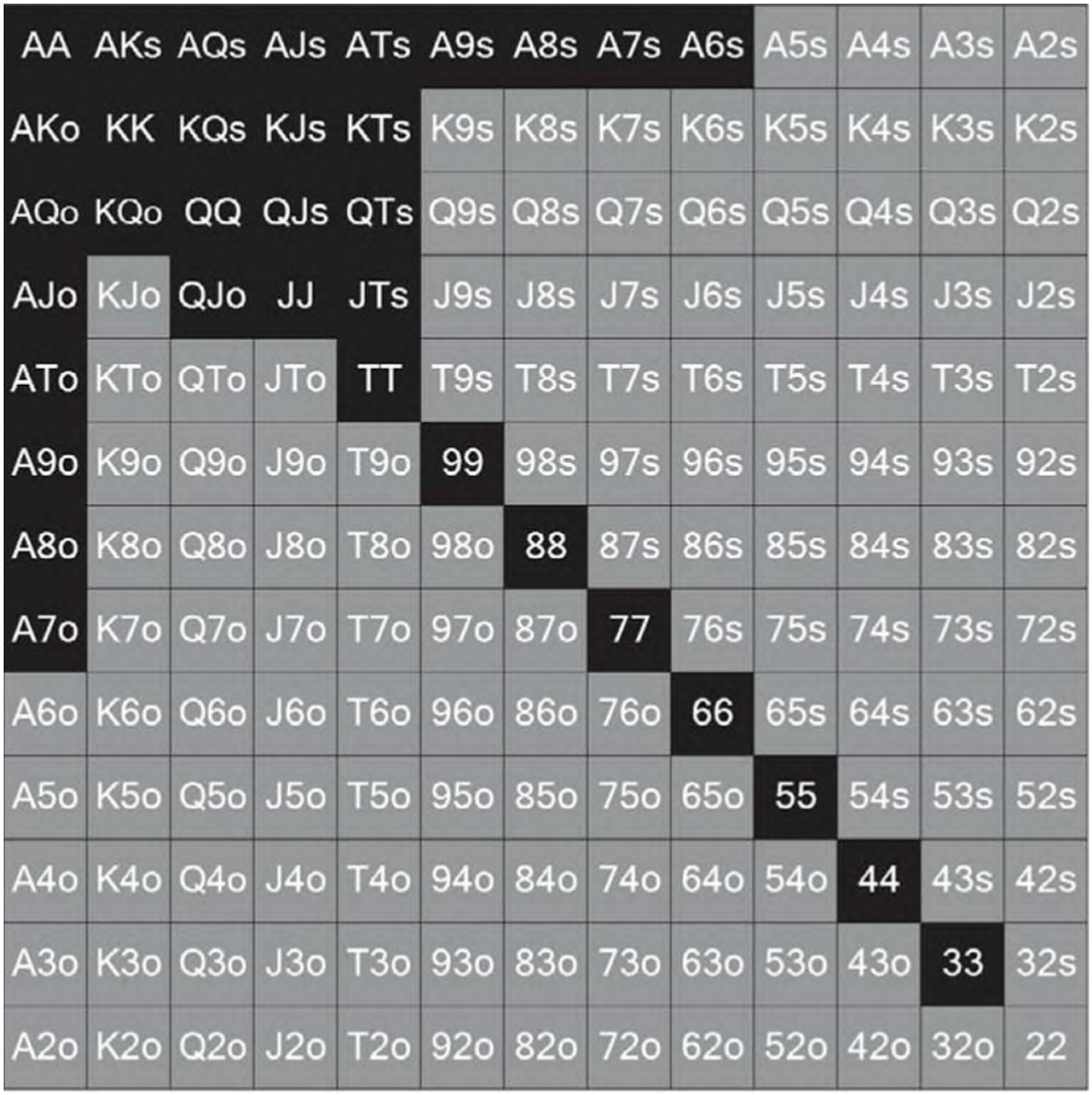
The simplest situation the BB can face is when the SB open jams. In that case, the BB's calling range depends on the pot odds laid by the SB's stack size. The fewer chips the SB is going all-in for, the more hands in BB's range that will have the correct equity to call, and the more chips SB is going all-in for, the fewer hands BB has to defend to remain unexploitable. For some who are experienced with push/fold apps, the unexploitable calling ranges may seem tighter than usual. This is due to a combination of factors such as the bunching effect and the fact that the SB has other strategic options (limping or raising to non-all-in sizes) which has a drastic effect on both calling and pushing ranges.

At 12bb when facing an all-in, the BB calls all pocket pairs, Ax, broadways, Kxs, K5o+, Q7s+, J8s+ and T8s+. This tightens up a little at 15bb *(Hand Range 140)*. At 25bb, the BB cannot profitably call as many hands, so the calling range shrinks to pocket pairs 33+, A7o+, A6s+, suited broadways, KQo and QJo (QJo has more equity vs SB equilibrium push range than KJo) *(Hand Range 141)*.

At equilibrium with fewer than 30bb, the BB's only 3-bet size is all-in. The solver likes trapping with the bigger pairs 88+ and the rejamming range is made of high equity hands that have poor post-flop playability, such as small pairs 77-22 and offsuit Ax *(Hand Range 142)*.



Hand Range 140: BB vs SB Push (15bb) • Call 28.9% / • Fold 71.1%



Hand Range 141: BB vs SB Push (25bb) • Call 17.8% / • Fold 82.2%

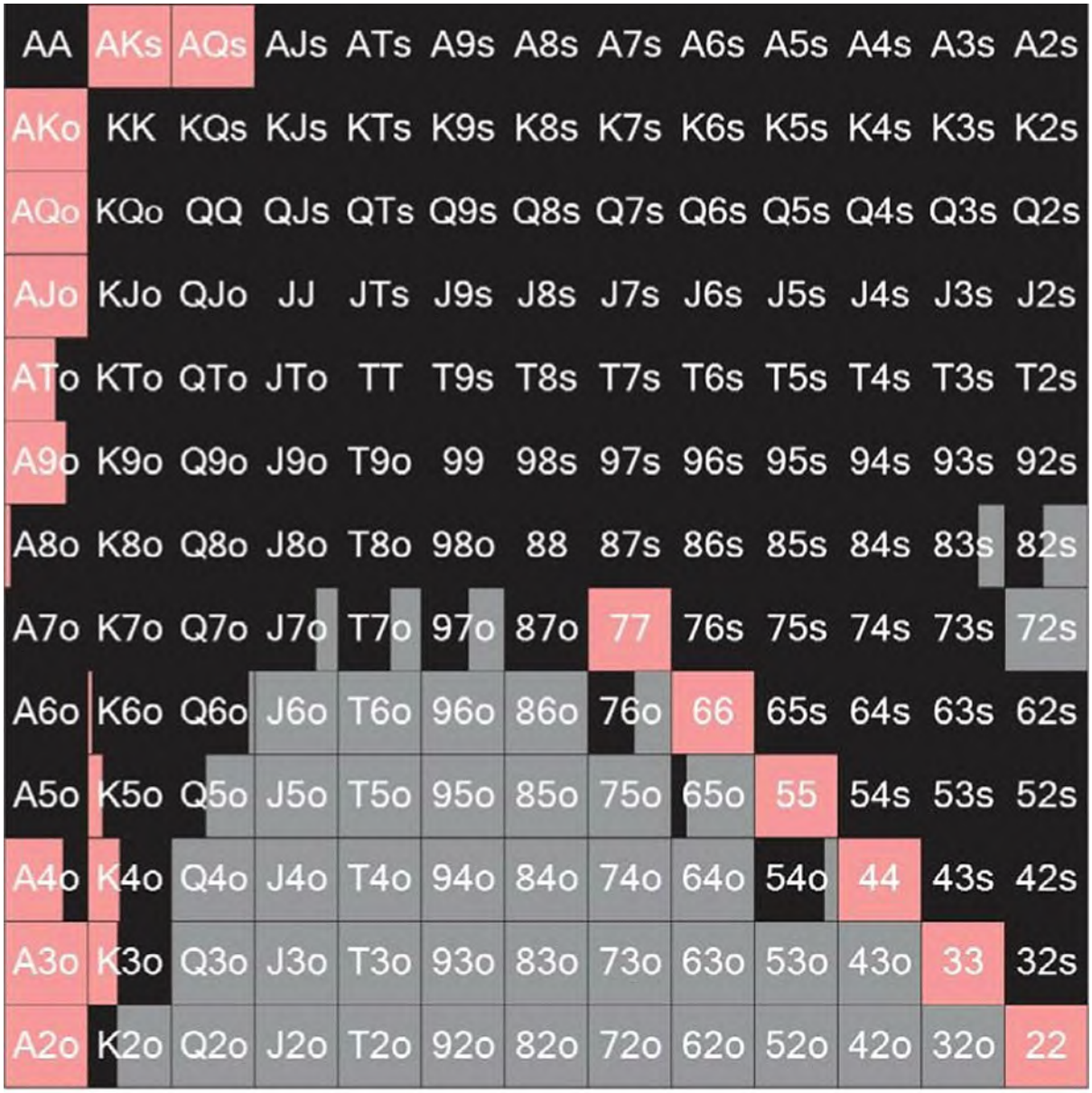
BB vs SB Raise

BB vs SB Raise	Raise Size	Actions Frequency			
Stack		All-in	3bet	Call	Fold
17bb	2.5x	15.40%	0.00%	62.70%	15.40%
20bb	2.5x	11.90%	0.00%	70.20%	17.90%
25bb	3.3x	10.60%	0.00%	53.80%	35.60%
30bb	3.5x	5.40%	7.00%	49.40%	38.20%
40bb	3.5x	0.00%	12.30%	52.00%	35.70%
60bb	3.5x	0.00%	12.00%	54.30%	33.60%
80bb	3.5x	0.00%	12.30%	55.30%	32.30%

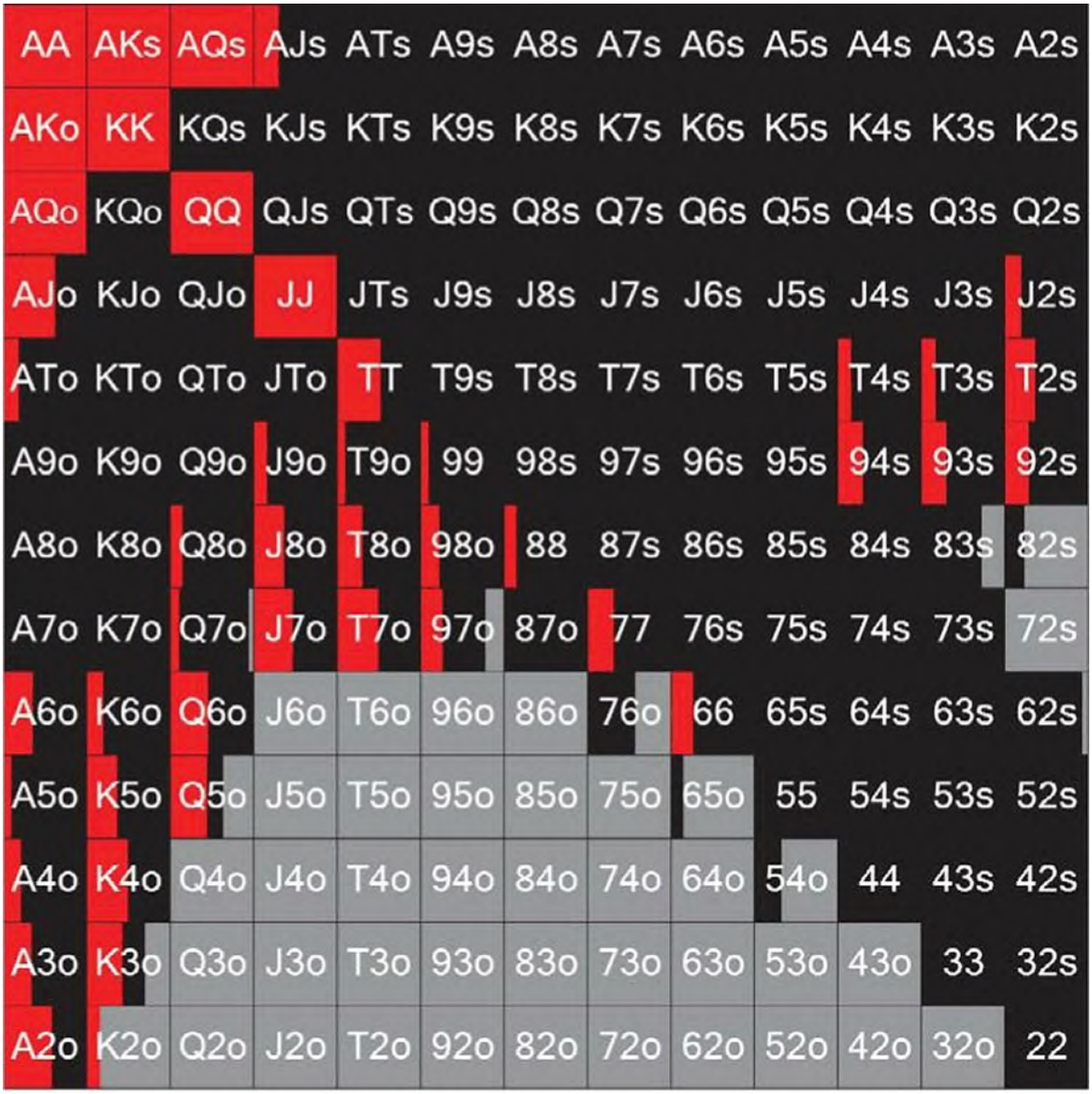
Table 57: BB vs SB Raise Action Frequencies

With 40bb, the solver no longer 3-bet jams all-in and the 3-betting strategy becomes more polarized, including the top of range, TT+ and AJ+, alongside a variety of bluffs made mostly of offsuit hands selected to have either good blockers, such as Axo and Kxo, or good board coverage such as J7o, T4s and 98o *(Hand Range 143)*. Against an all-in 4-bet, the BB calls off with 66+, AJs+ and ATo+ *(Hand Range 144)*.

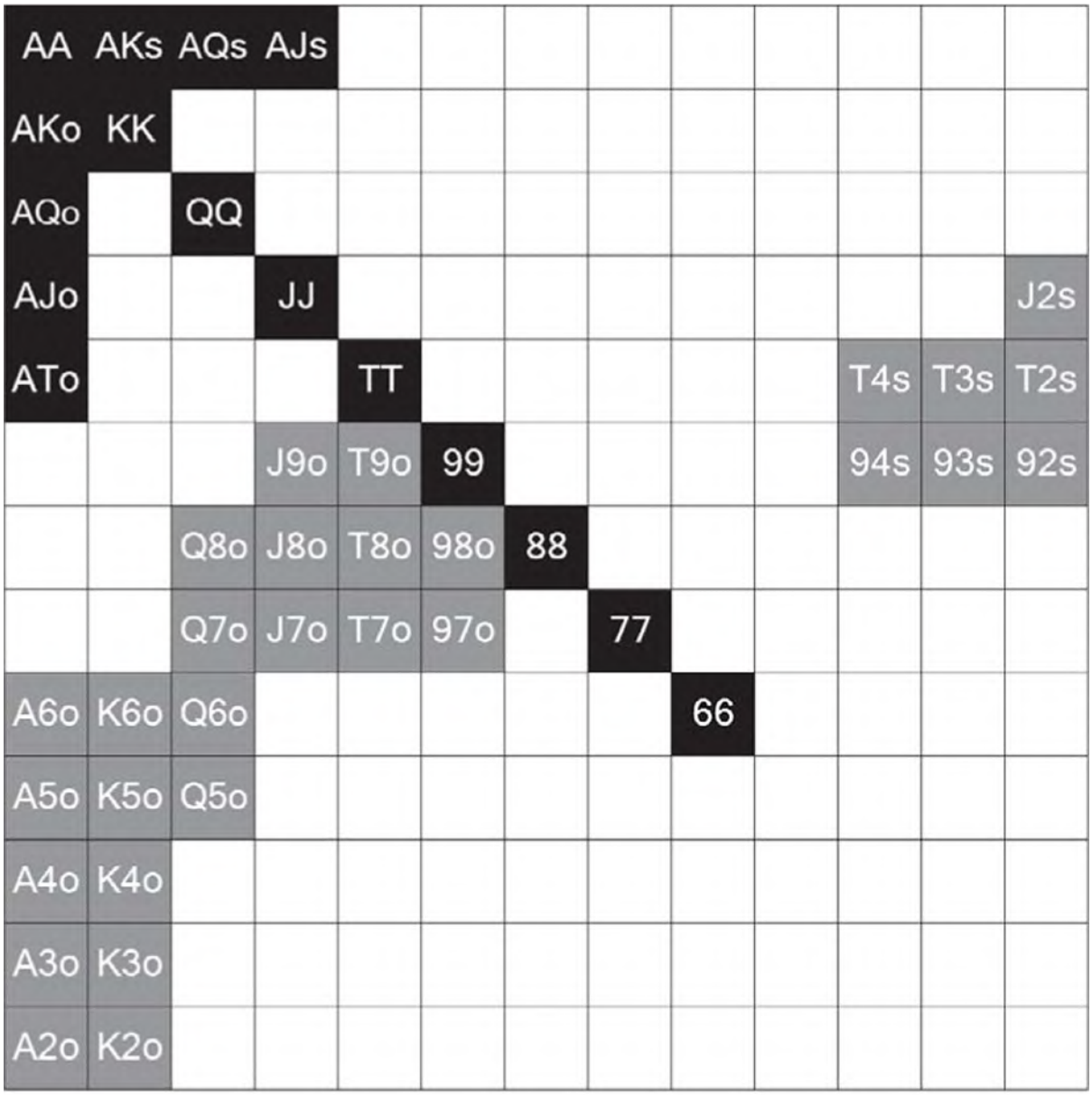
With 60bb, the BB 3-bets almost the same total frequency as with 40bb, but the composition of the bluffing portion of the range changes. This means 3-betting a smaller frequency of individual hands to include a wider variety of combos, providing better board coverage *(Hand Range 145)*. Against a 2.6x 4-bet, the BB 5-bets 27.4%, which is JJ+ and AQ+, but slowplays AA 68% of the time, calls with the best suited connectors, AJ and the smaller pocket pairs *(Hand Range 146)*.



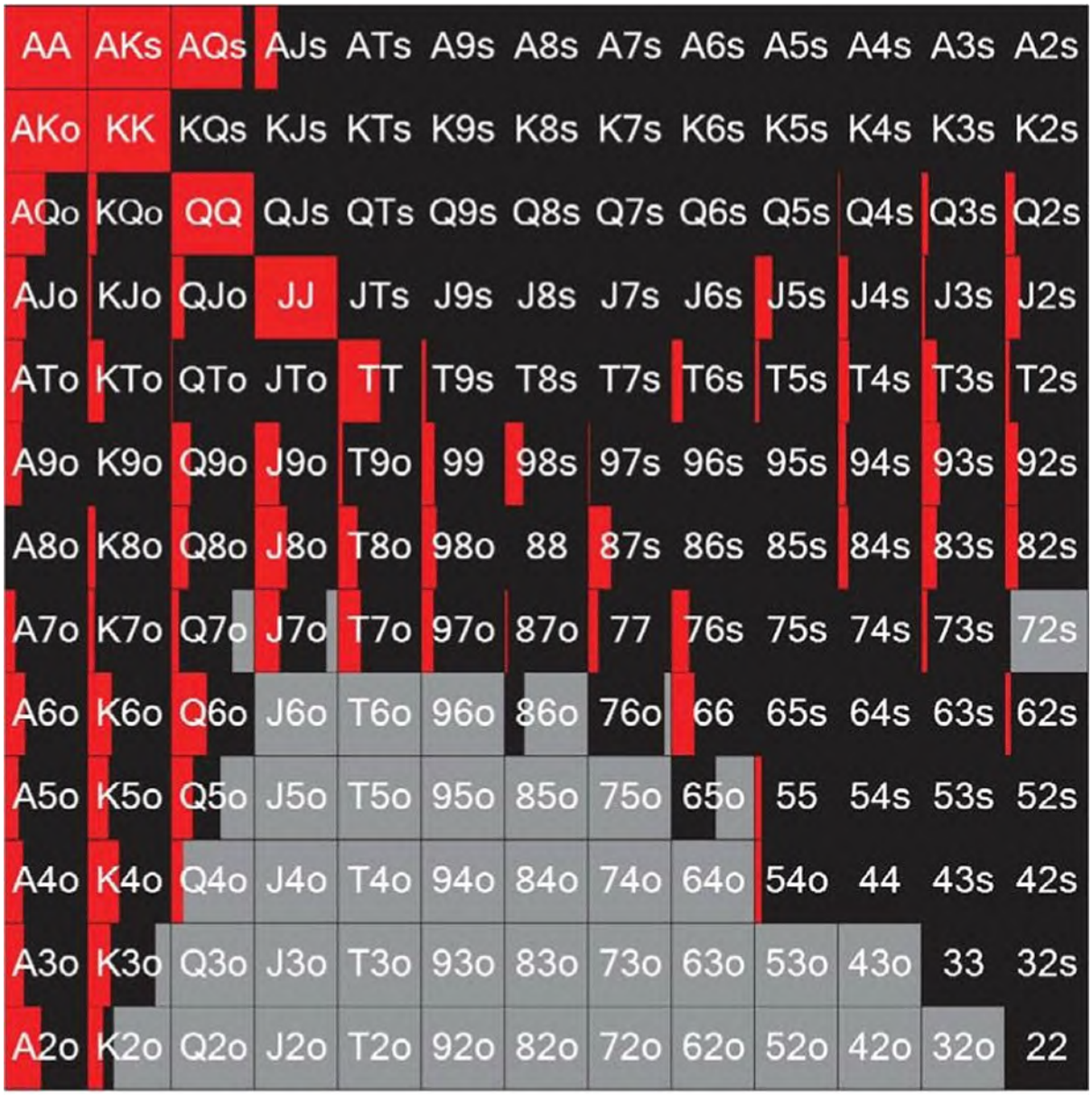
Hand Range 142: BB vs SB 3.3x Raise (25bb) • All-in 10.6% / • Call 53.8% / • Fold 35.6%



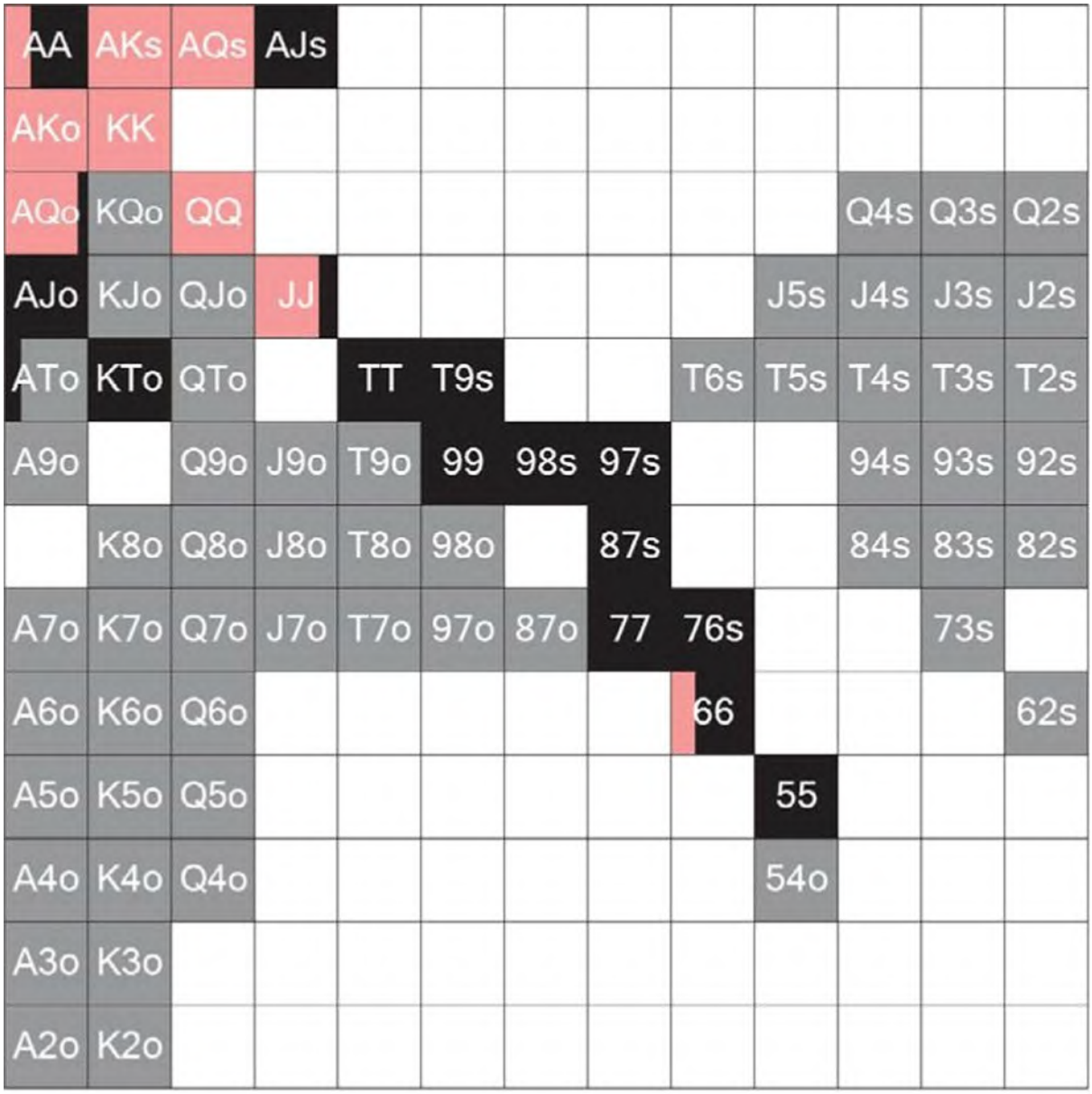
Hand Range 143: BB vs SB 3.5x Raise (40bb) • 3-bet 12.3% / • Call 52% / • Fold 35.7%



Hand Range 144: BB vs SB 4Bet (40bb) • Call 46% / • Fold 54%



Hand Range 145: BB vs SB 3.5x Raise (60bb) • 3-bet 12.1% / • Call 54.3% / • Fold 33.6%



Hand Range 146: BB vs SB 4-bet (60bb) • All-in 27.4% / • Call 14.2% / • Fold 58.5%

BB vs SB Limp

BB vs SB Limp	Actions Frequency			
Stack	All-in	Raise (Non All-in)	Raise Size	Check Back
10bb	29.60%	16.40%	2x	53.90%
12bb	20.30%	25.20%	2.5x	54.50%
15bb	8.20%	33.70%	3x	58.10%
17bb	10.40%	33.60%	3x	56.00%
20bb	7.60%	34.40%	3x	58.00%
25bb	4.40%	37.80%	3.3x	57.80%
30bb	2.10%	40.80%	3.5x	57.10%
40bb	0.00%	44.00%	3.5x	56.00%
60bb	0.00%	43.80%	3.5x	56.20%
80bb	0.00%	43.70%	3.5x	56.30%

Table 58: BB vs SB Limp Action Frequencies

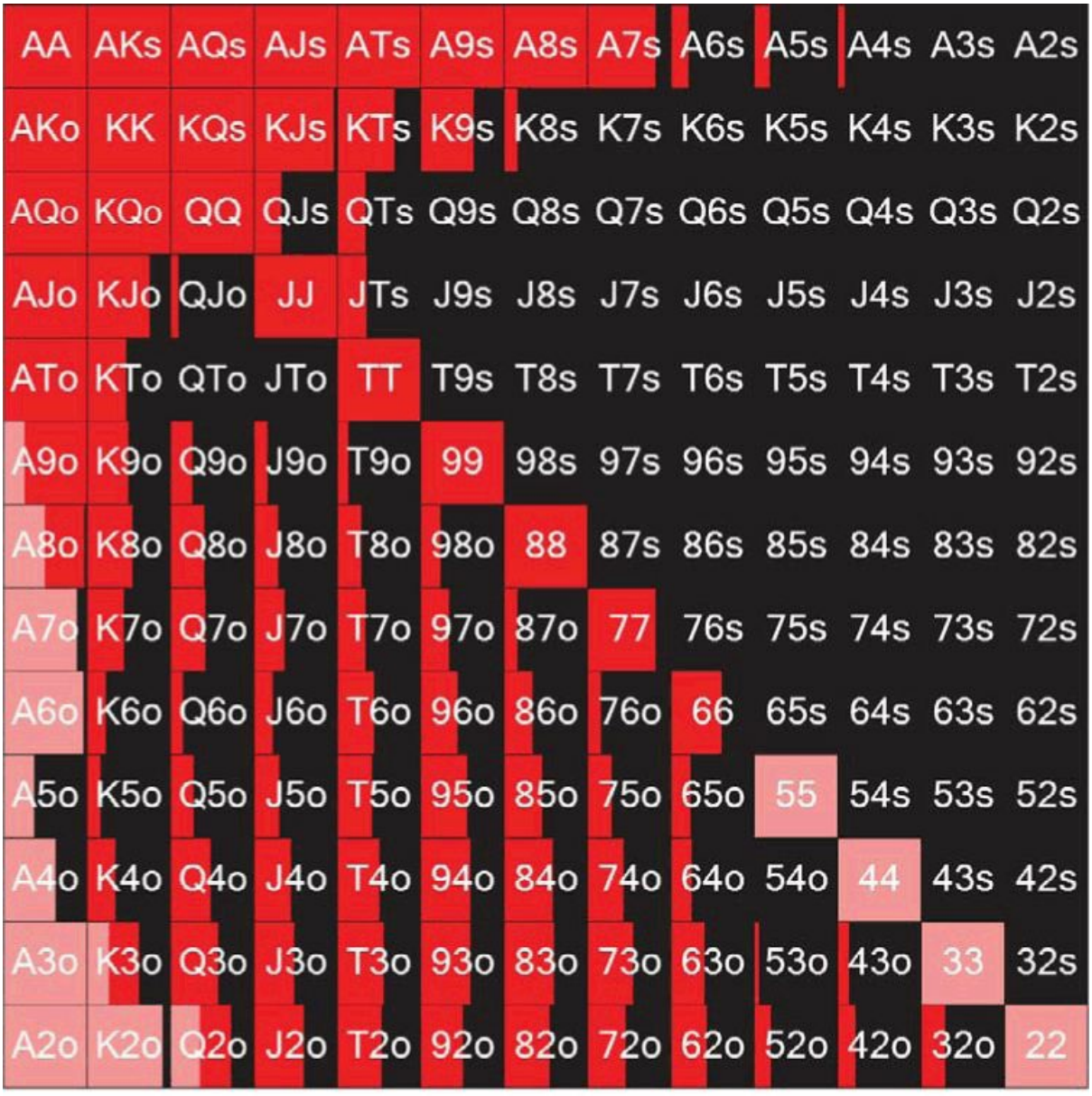
The BB checks back on average 56% vs a SB limp and raises 44%. The raise size increases as stacks get deeper, going from 2x at 10bb to 3.5x at 30bb. At deeper stack depths, the solver likes going even bigger, but there is not a significant drop in EV using 3.5x at all stacks deeper than 30bb. I believe that using bigger bet-sizes is overkill, particularly in today's environment where population limping strategies are highly unbalanced and over-fold to BB raises. In fact, even smaller bet-sizes can and should be used exploitatively vs weak players.

With 12bb, the BB goes all-in 20.3%, raises to 2.5x 25.2% and checks back 54.5%. The all-in range contains hands with good blockers and high equity but very bad post-flop equity realization such as small pocket pairs, and offsuit Ax and Kx. The raising range is polarized, made of hands that are happy to raise/call and a variety of hands with good board coverage that are fine to raise/fold. At this stack depth, the solver checks back any suited hand that is not happy to raise/call so the BB doesn't have equity denied when jammed on. The 15bb range *(Hand Ranges 147-148)* is tighter but similar.

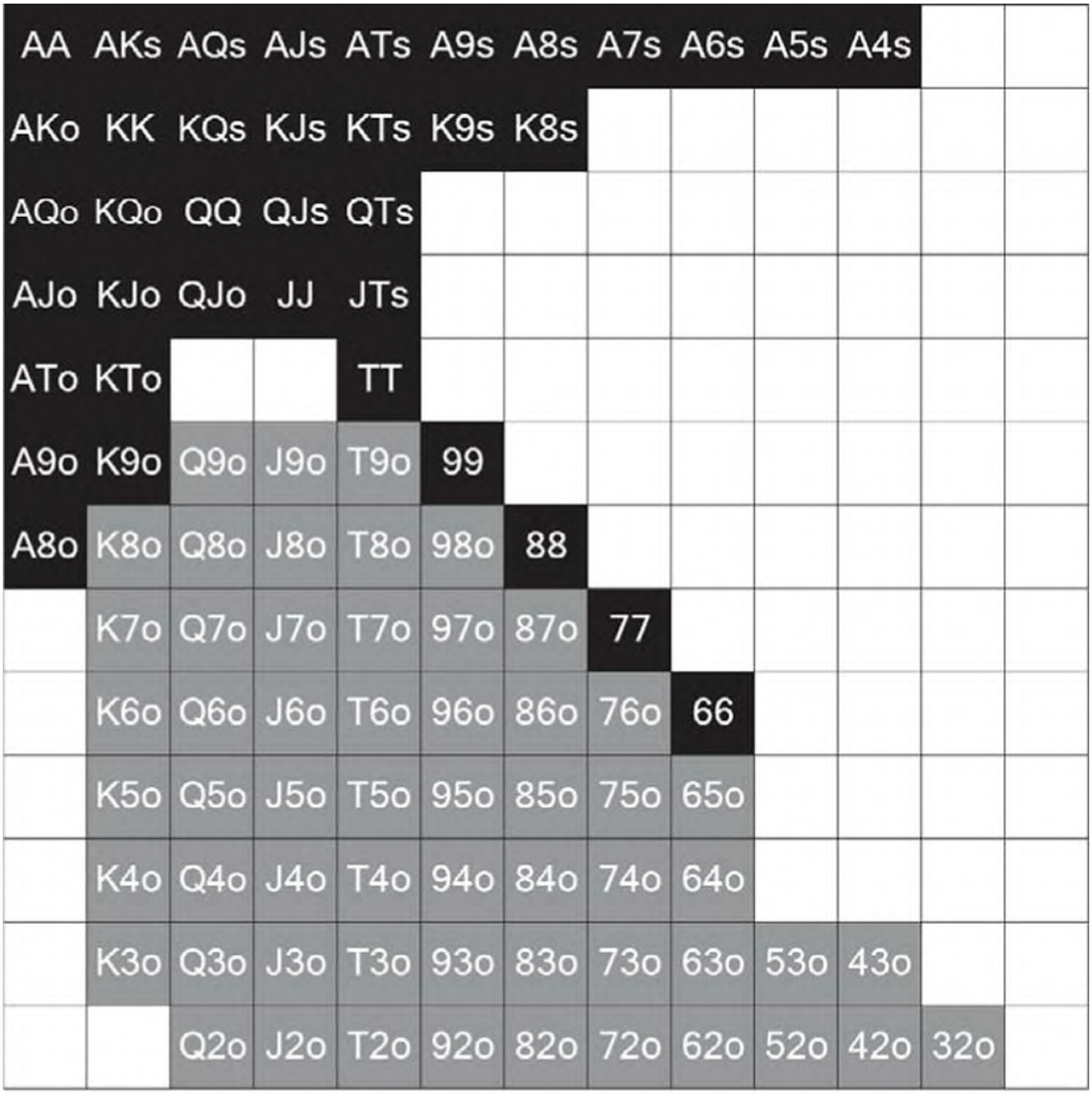
With 25bb, the BB jams at a lower frequency than at 12bb, but the hands the solver chooses to jam follow the same pattern of hands with blockers with bad post-flop equity realization as well as small pocket pairs. The raising range includes a small frequency of some of the worst suited hands such as J4s, 96s and 62s that give the BB better post-flop playability *(Hand Ranges 149-150)*.

With 40bb and 60bb, the BB has no all-in range vs a SB limp, and the raising range includes a wider variety of both suited and offsuit hands that have a combination of blockers and good

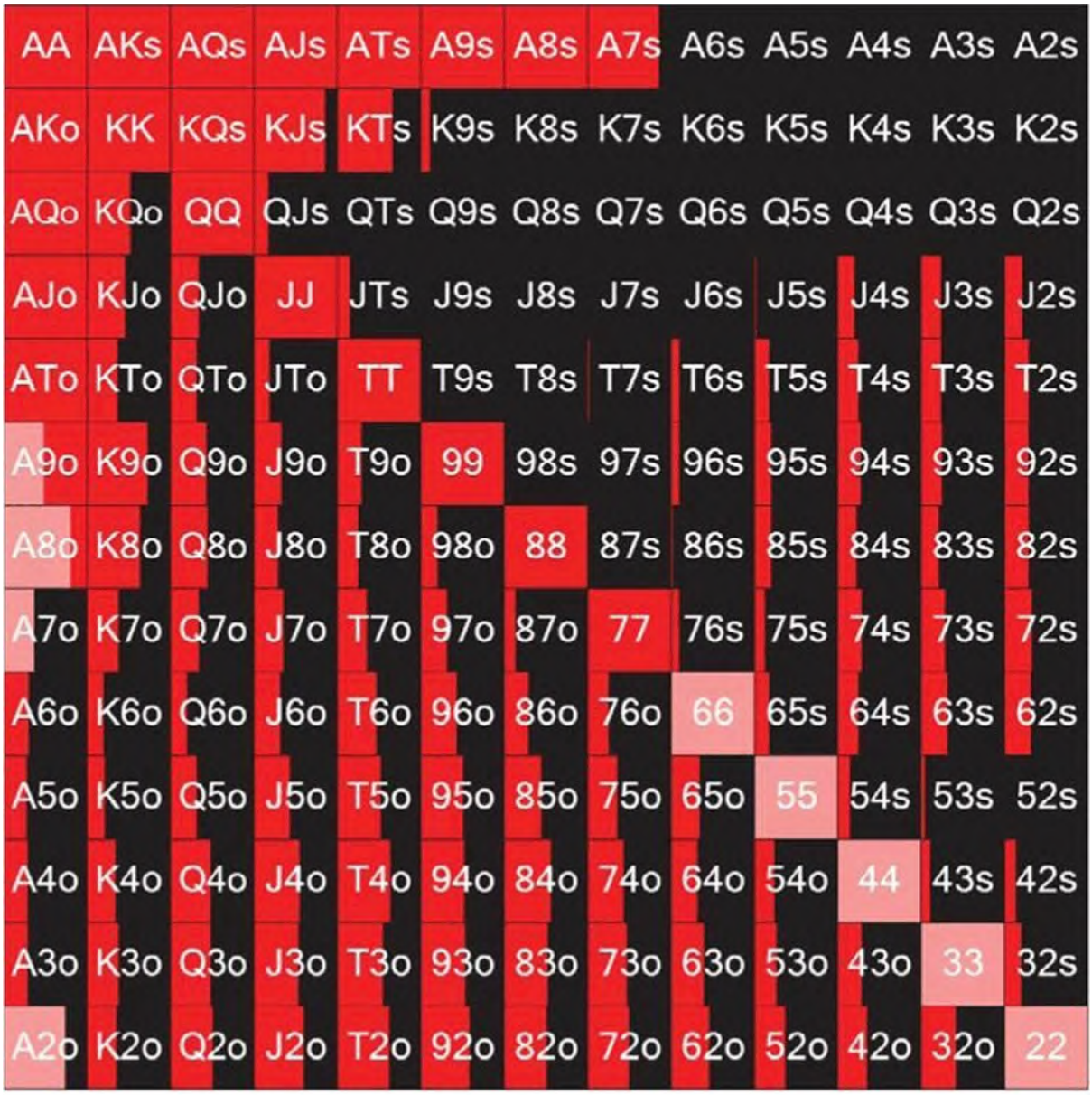
board coverage. These stack depths are deep enough for the BB to call a SB limp/raise with many suited hands due to being in position, so being re-raised isn't such a disaster because the best suited hands can always call and play post-flop *(Hand Ranges 151-154)*.



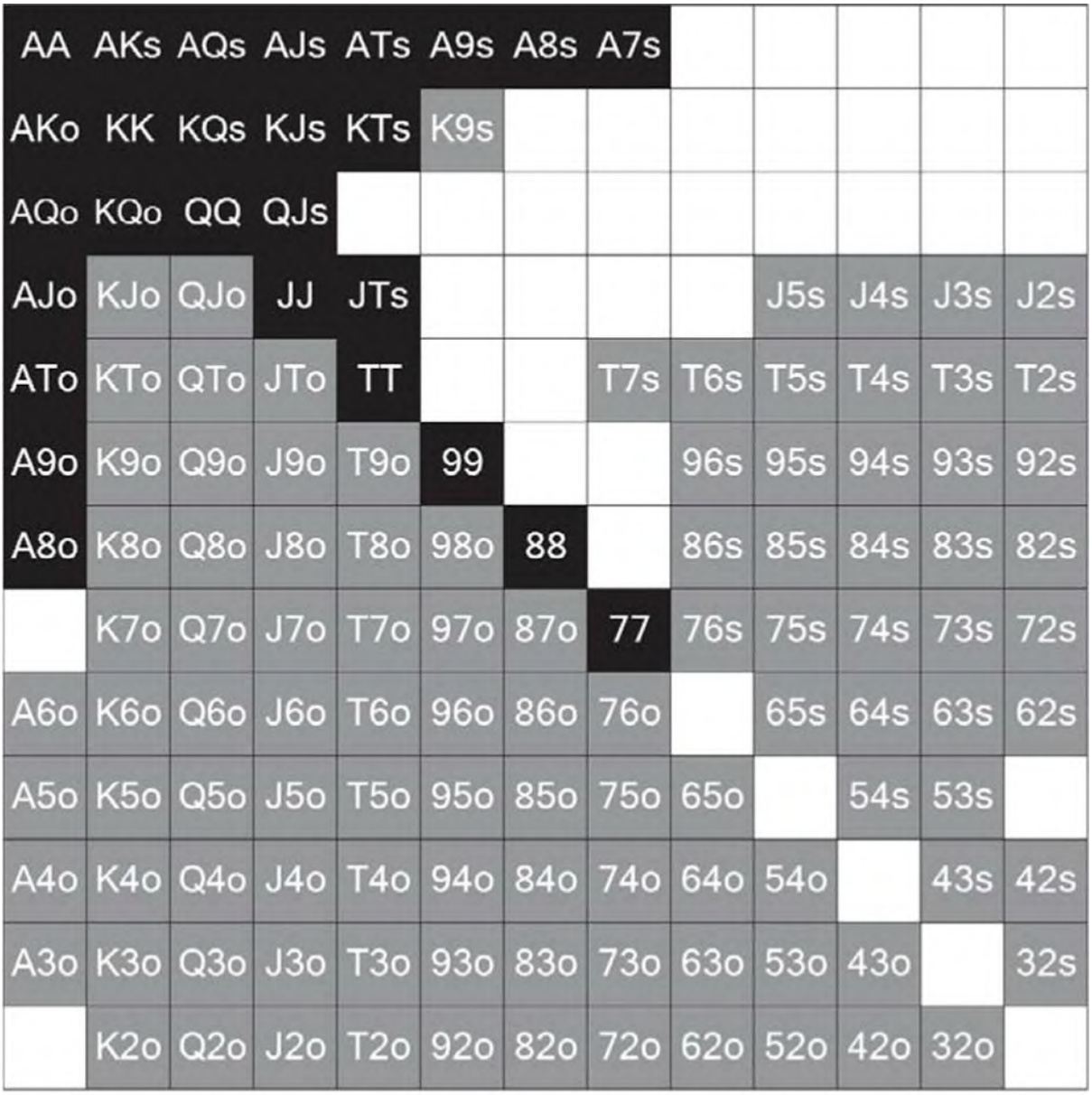
Hand Range 147: BB vs SB Limp (15bb) • All-in 8.2% / • Raise 3x 33.7% / • Check 58.1%



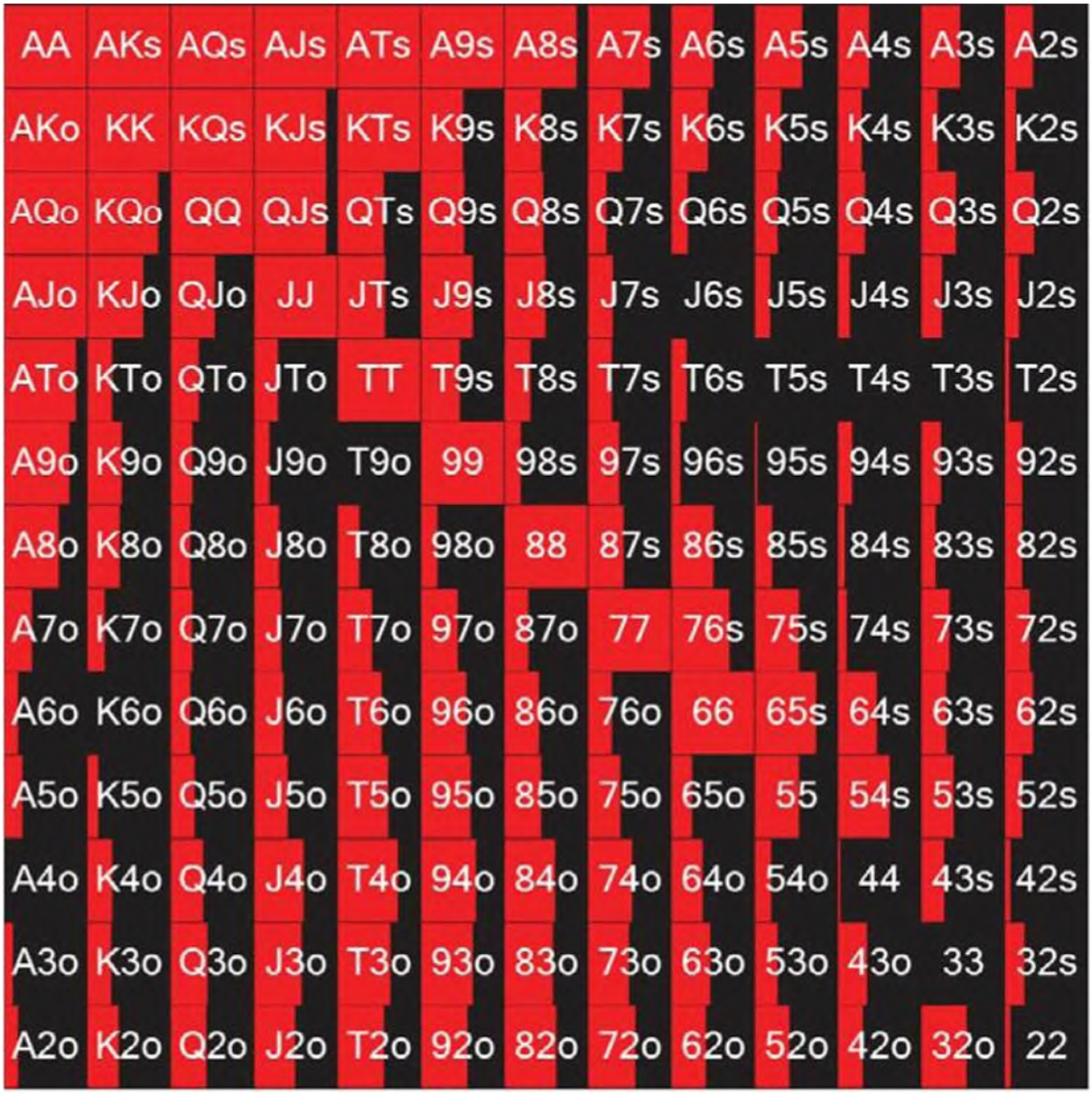
Hand Range 148: BB vs SB Limp/Push (15bb) • Call 43.4% / • Fold 56.6%



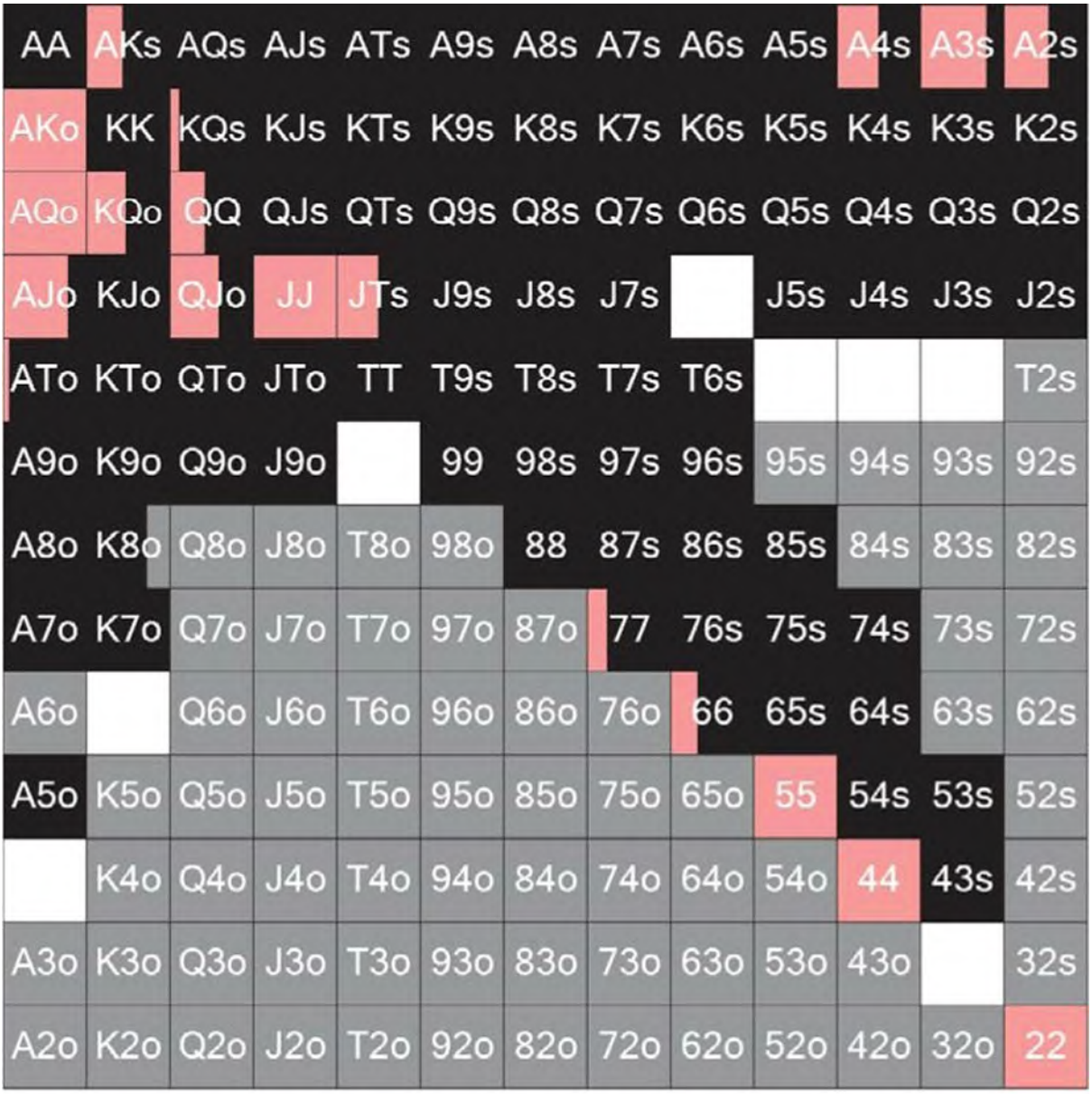
Hand Range 149: BB vs SB Limp (25bb) • All-in 4.4% / • Raise 3.3x 37.8% / • Check 57.8%



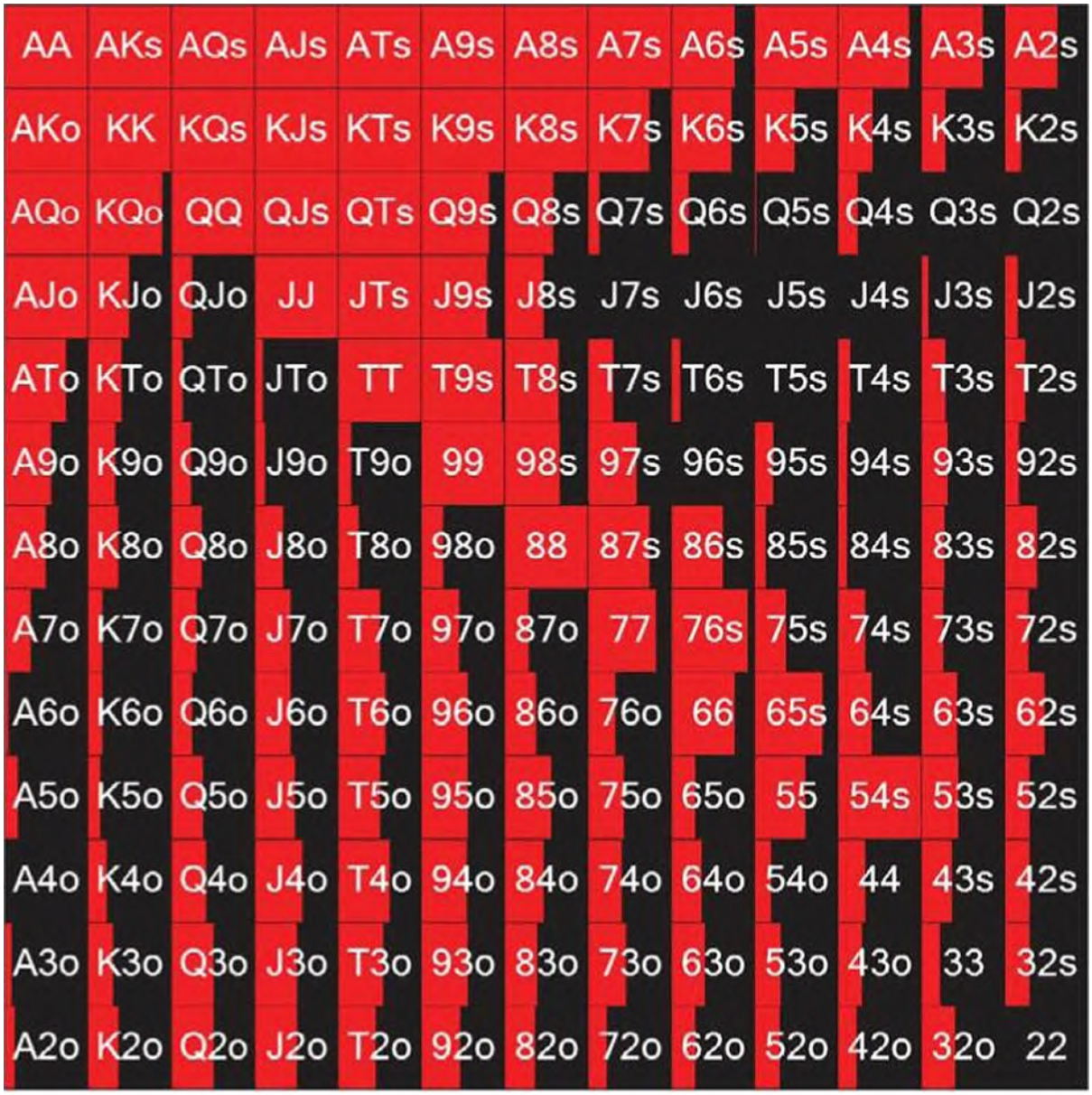
Hand Range 150: BB vs SB Limp-Push (25bb) • Call 29.8% / • Fold 70.2%



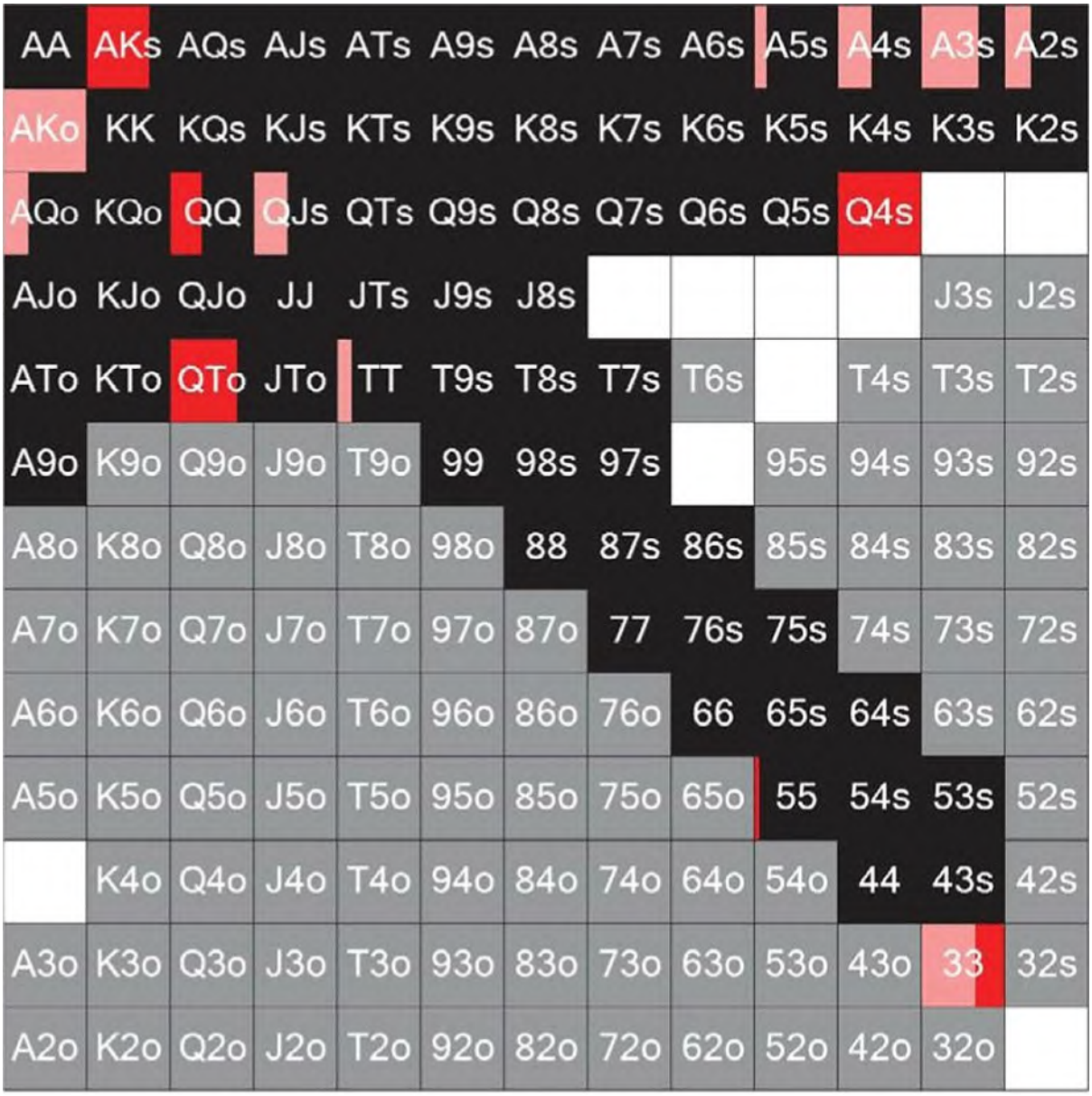
Hand Range 151: BB vs SB Limp (40bb) • Raise 3.5x 44% / • Check 56%



Hand Range 152: BB vs SB Limp-Raise (40bb) • All-in 11.1% / • Call 39.3% / • Fold 49.6%



Hand Range 153: BB vs SB Limp (60bb) • Raise 3.5x 43.8% / • Check 56.2%



Hand Range 154: BB vs SB Limp-Raise (60bb) • All-in 4.1% / • 4-bet 2.2x 1.4% / • Call 41.5% / • Fold 53%

Defending the Big Blind Versus IP Player

BB vs	All-in	Call	Fold
BN	18.00%	58.20%	23.80%
CO	16.40%	60.40%	23.20%
HJ	13.90%	64.10%	22.00%
LJ	11.00%	66.70%	22.30%
UTG+2	9.70%	68.20%	22.10%
UTG+1	8.30%	69.20%	22.50%
UTG	7.40%	70.60%	22.00%
Average	12.10%	65.34%	22.56%

Table 59: BB vs IP Action Frequencies (15bb)

Defending the BB Versus IP (15bb)

With 15bb, the average BB fold vs a min-raise is 22.56%. At this stack depth, the BB is too shallow to have a non-all-in 3-betting range. Something interesting to note is how the all-in frequency decreases as the opponent's range gets stronger, going from 18% vs the BN to only 7.4% vs UTG, but the overall BB VPIP frequency remains constant because the BB calling frequency increases as the all-in frequency decreases.

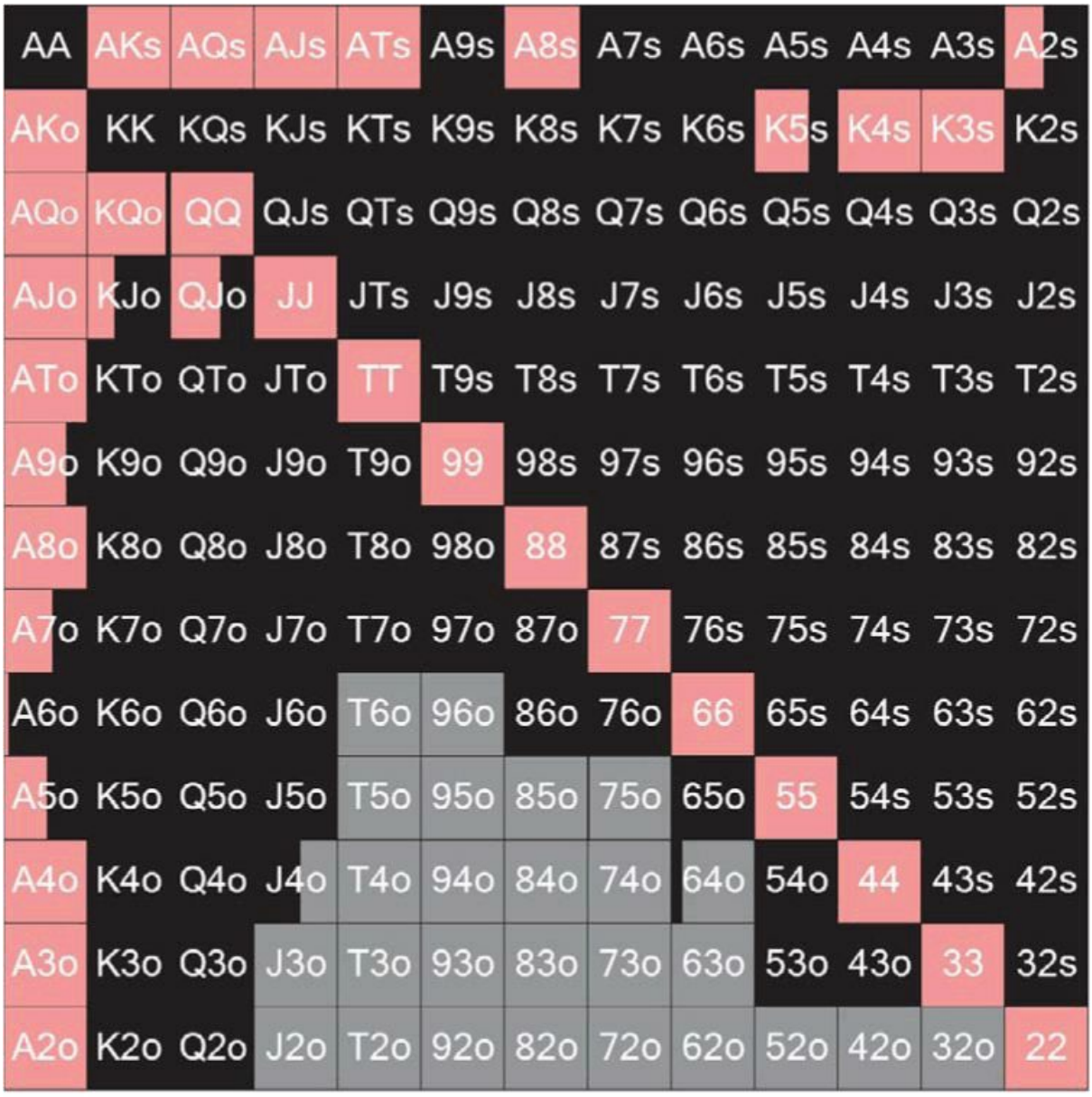
The solver likes going all-in pre-flop at this stack depth with hands that are ahead of the opener's range but have bad post-flop equity realization and thus perform better by getting the money in pre-flop. Most pocket pairs make great rejamming hands except AA and KK, which get slowplayed vs LP, and the smaller pairs are played using a mixed strategy vs EP. Offsuit Ax are great rejams vs LP, but the fold equity vs EP is lower and so they get replaced by suited Ax.

> *It's important to notice how observing the kicker can help understand the way the solver chooses to rejam hands with blockers.*

For example, hands such as KQs have great equity vs calling ranges, but the solver likes calling it from the BB vs all positions, even vs a wide range from the BN. Instead, the solver rejams K5s-K3s. The reason for this is simply that the stronger Kx will have a higher chance of coolering the BN post-flop, plus they have way more post-flop playability, significantly increasing their equity realization. So, when choosing which king-high blockers to use, the solver prefers the ones with weak kickers that benefit from having fold equity yet still have fine equity against the opponent's calling range.

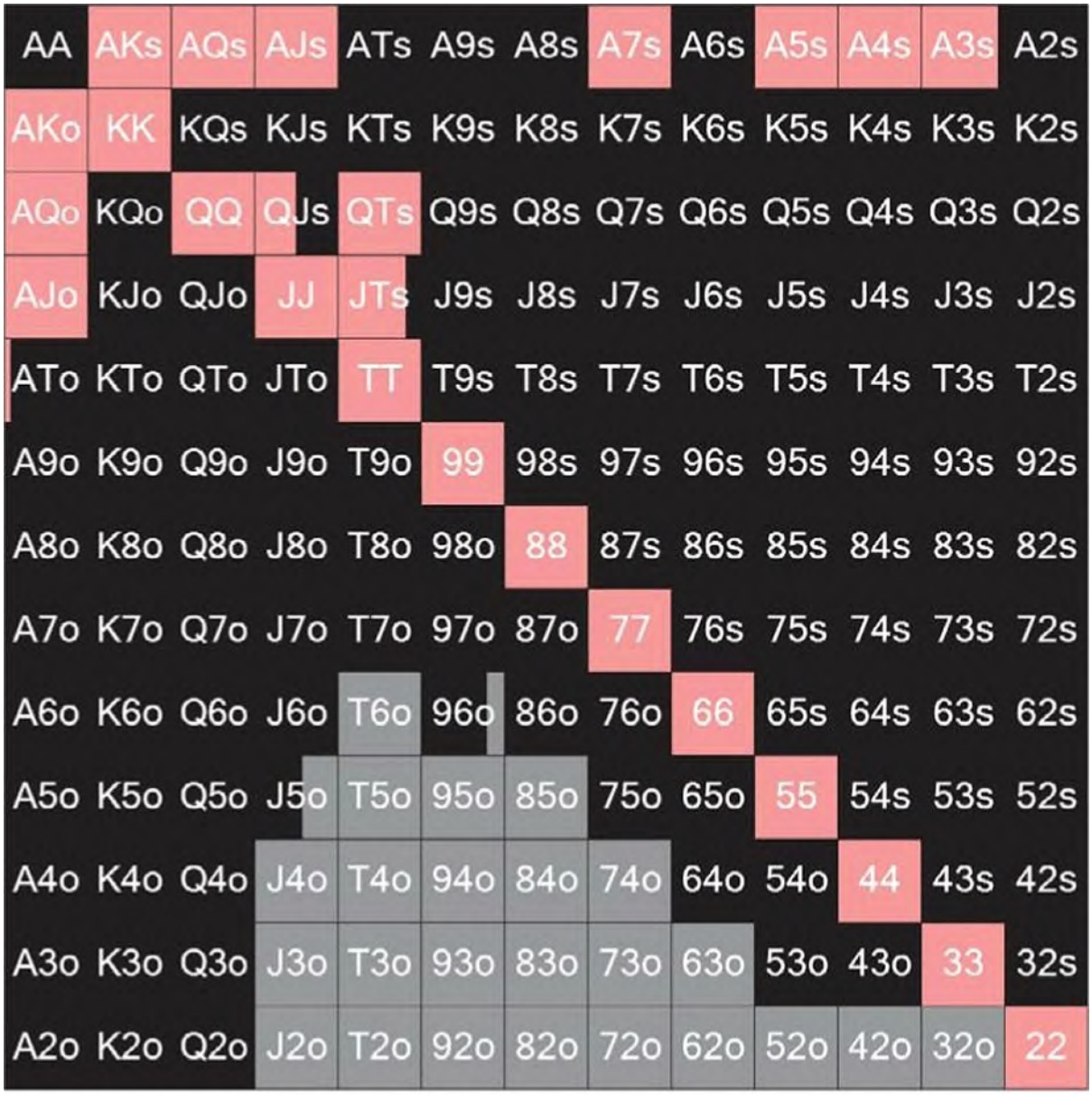
A similar effect can be seen with other hands. As an example, against a LJ raise, the solver

will choose to rejam the top of the range (AKs-AJs), flat (ATs-A6s and A2s) and then rejam (A5s-A3s). The hands in the top of the range such as AKs are simply too strong not to rejam, hands in the middle such as A9s play well post-flop and will dominate a lot of the BN range, while A4s makes a great rejamming hand because it benefits from having fold equity and will fare well enough vs the LJ calling range *(Hand Ranges 155-158)*.

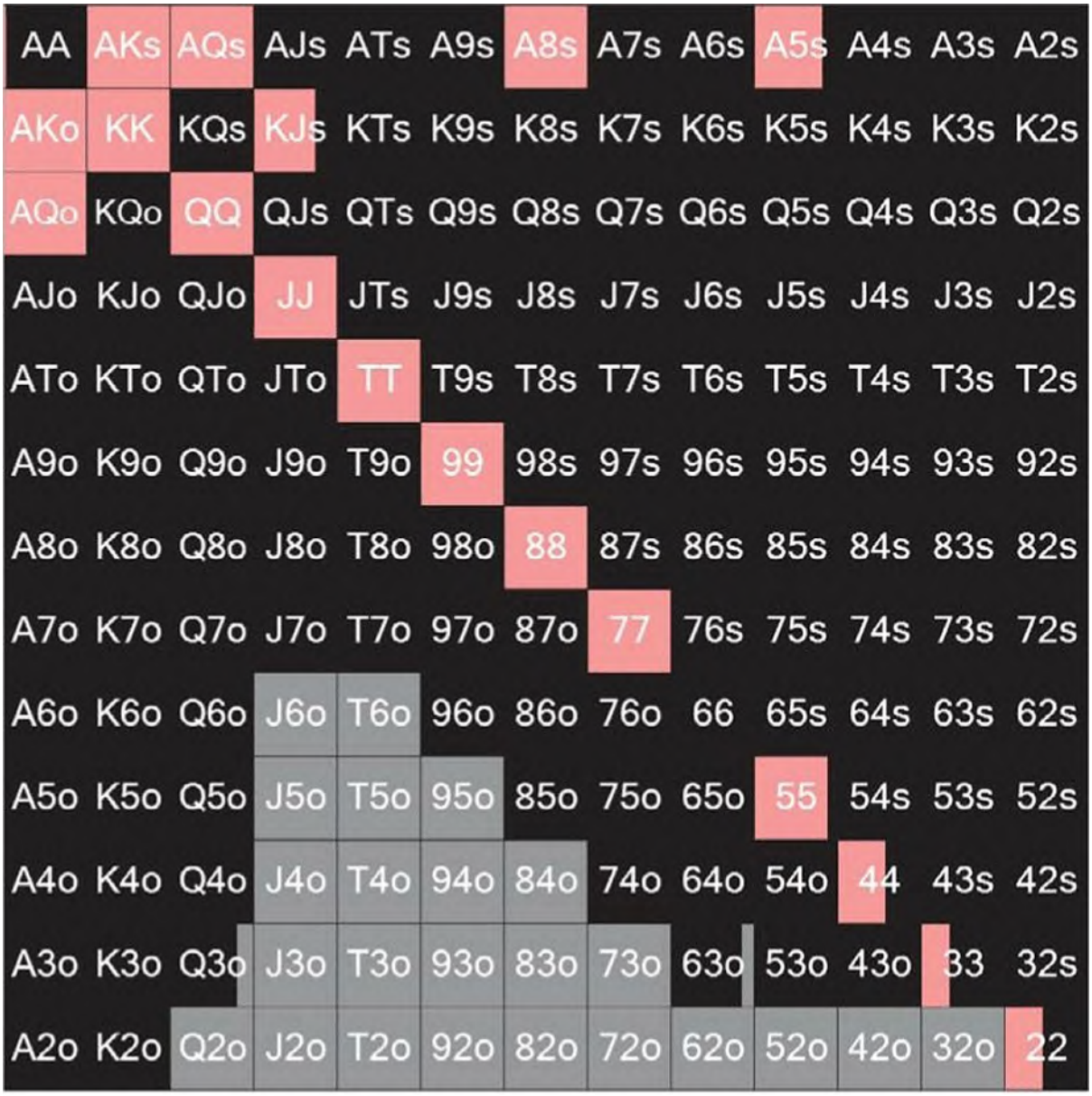


Hand Range 155: BB vs BN (15bb) • All-in 18% / • Call 58.2% / • Fold 23.8%

Hand Range 156: BB vs CO (15bb) • All-in 16.4% / • Call 60.4% / • Fold 23.2%



Hand Range 157: BB vs LJ (15bb) • All-in 11% / • Call 66.7% / • Fold 23.3%



Hand Range 158: BB vs UTG (15bb) • All-in 7.4% / • Call 70.6% / • Fold 22%

Defending the BB Versus IP (25bb)

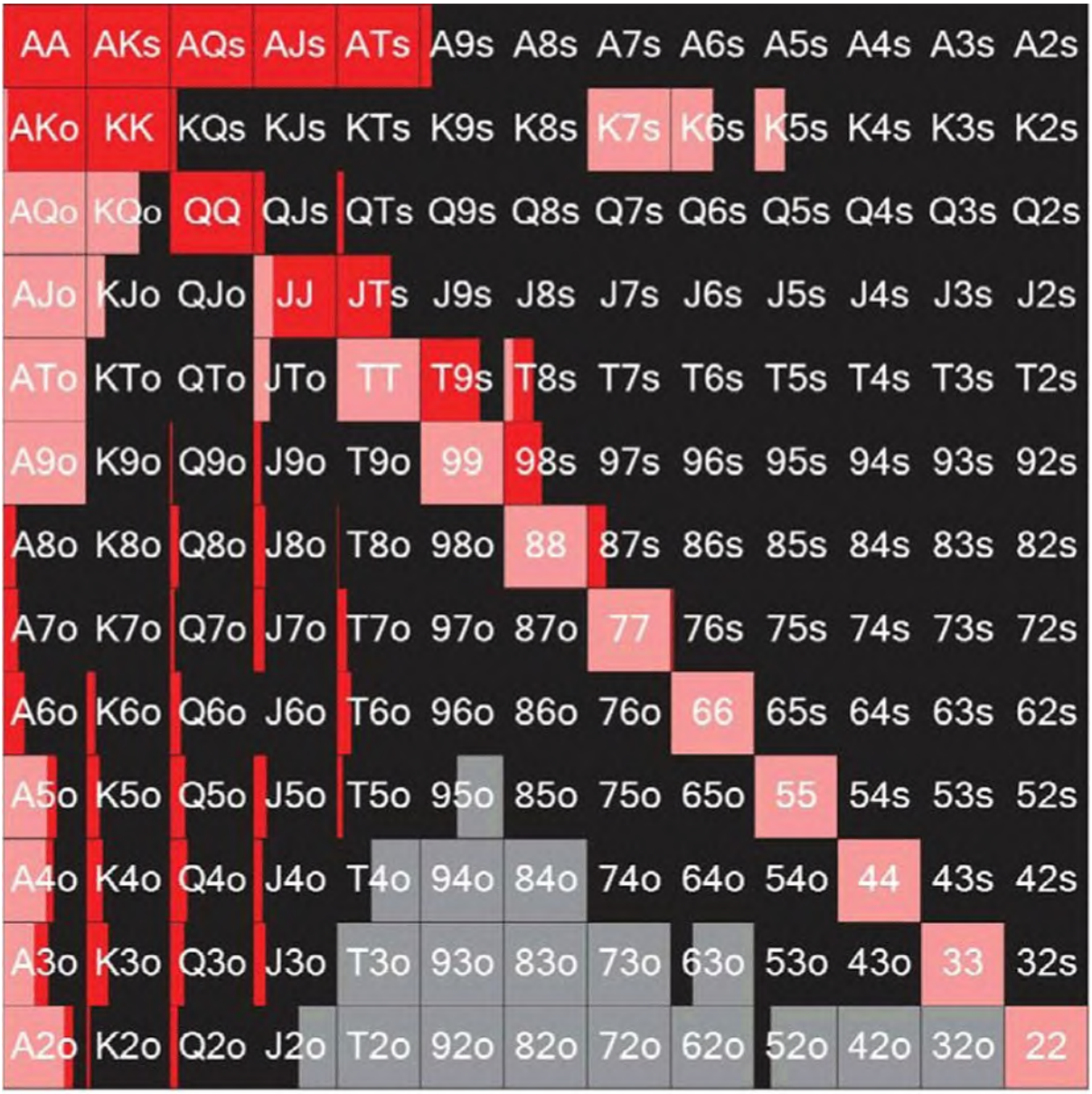
BB vs	All-in	3-bet	Call	Fold
BN	11.40%	8.20%	65.90%	14.60%
CO	8.80%	5.50%	67.10%	18.60%
HJ	7.00%	5.20%	65.90%	21.90%
LJ	5.10%	5.00%	66.80%	23.20%
UTG+2	4.40%	4.70%	66.20%	24.28%
UTG+1	2.90%	4.90%	64.30%	28.00%
UTG	2.10%	4.70%	66.00%	27.20%
Average	5.96%	5.46%	66.03%	22.54%

Table 60: BB vs IP Action Frequencies (25bb)

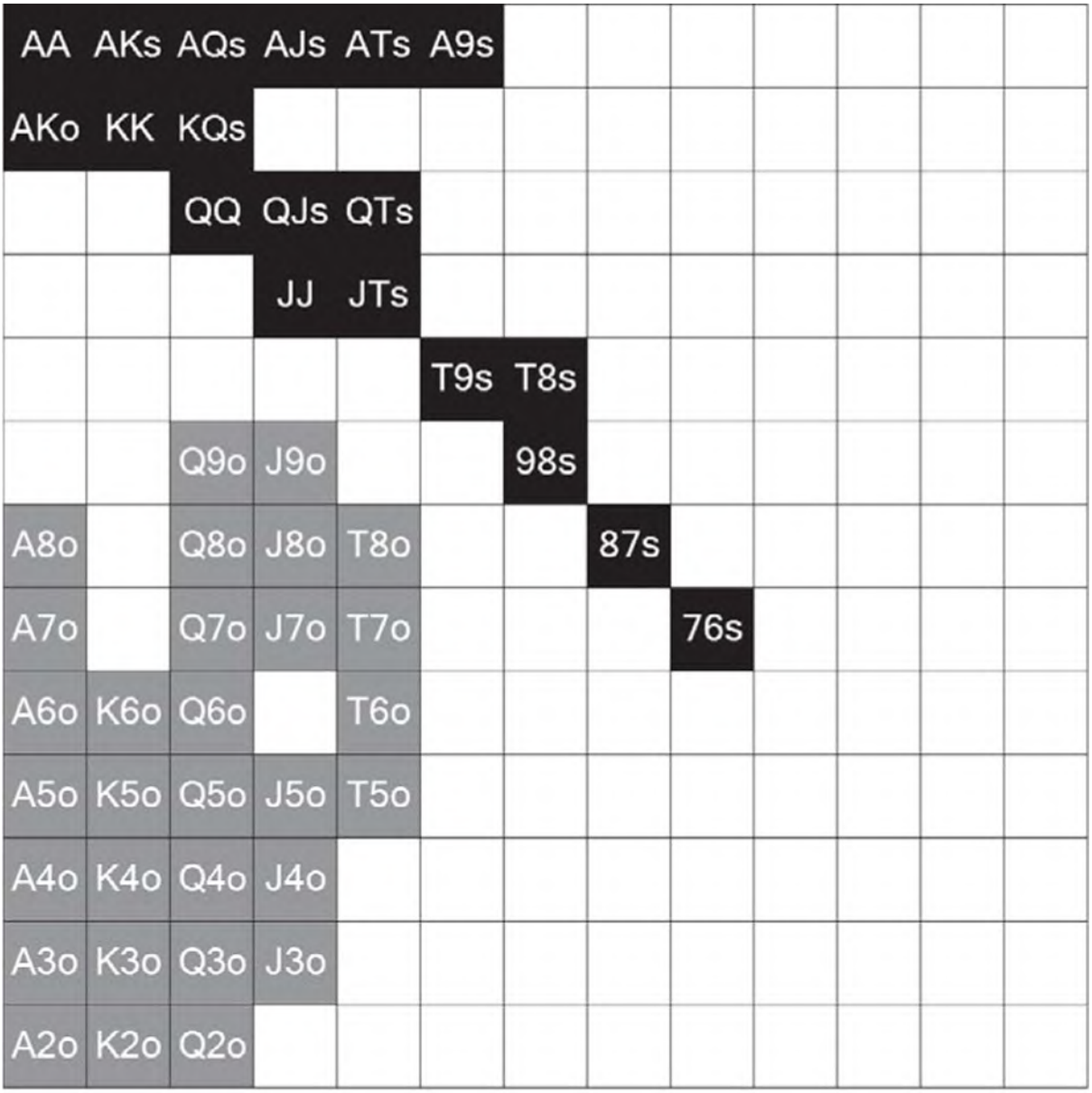
With 25bb, the average BB fold vs a min-raise is 22.54%, increasing from 14.6% vs the BN to 27.2% vs UTG. The BB all-in frequency drops as the opener's range gets stronger, from 11.4% vs the BN to only 2.1% vs UTG, but the non all-in 3-bet frequency remains fairly constant at around 5%, except vs the BN, which is the highest at 8.20%.

Pocket pairs and Axo really like getting all-in. As the opener's range widens, the weaker pairs and Ax get to shove. The non-all-in 3-betting range is polarized, made of JJ+, the strongest Axs, some of the best premium suited connectors, and a small frequency of offsuit hands with a blocker, including A8o-A2o, K6o-K2o, Qxo and Jxo.

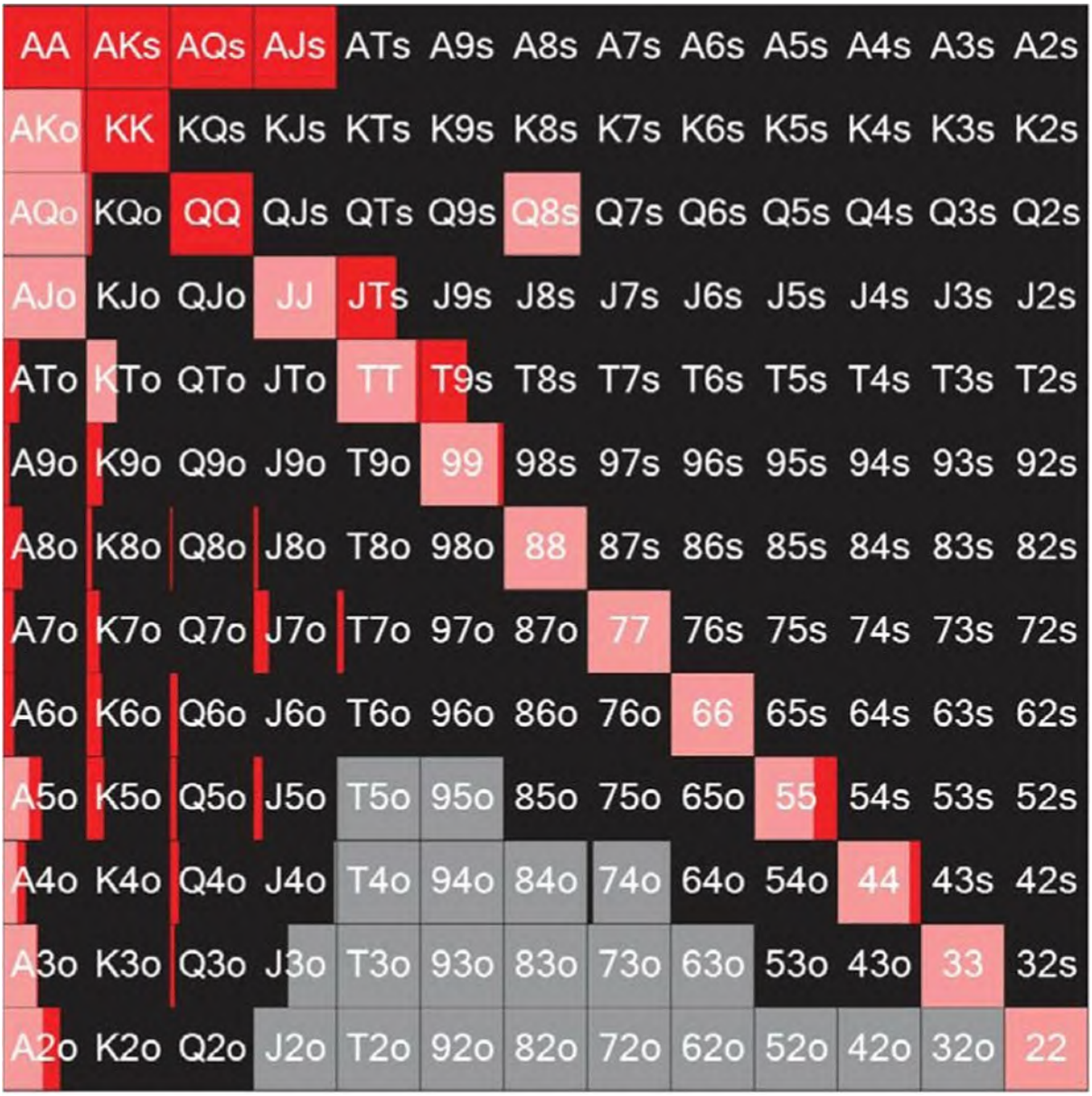
The folding range increases drastically as the opener's range gets stronger, from 14.6% up to 28% vs EP. This is because, at 25bb, stacks are deep enough that weak hands start having difficulty realizing their equity post-flop from OOP. *(Hand Ranges 159-166)*.



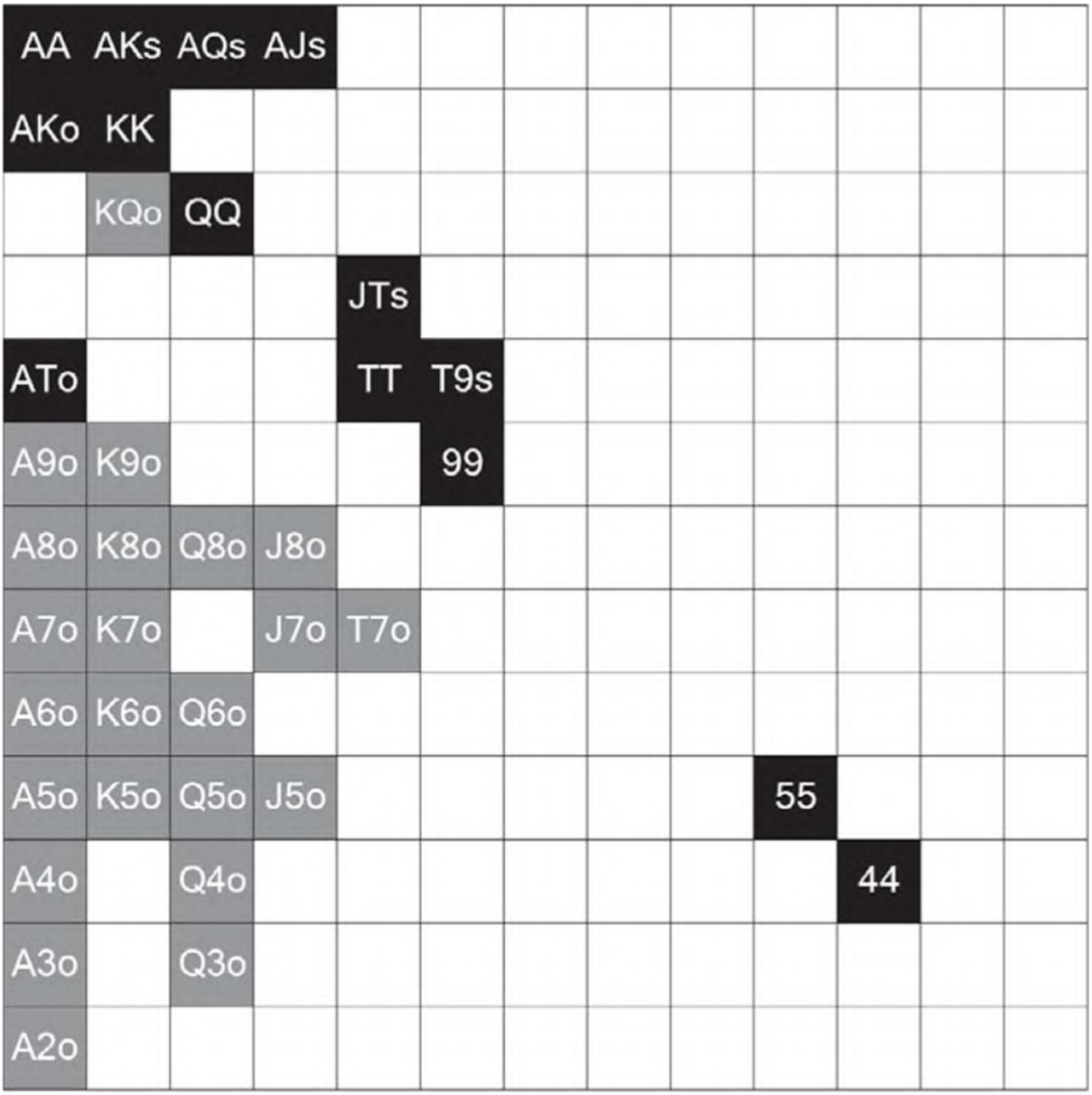
Hand Range 159: BB vs BN (25bb) • All-in 11.4% / • 3-bet 8.2% / • Call 65.9% / • Fold 14.6%



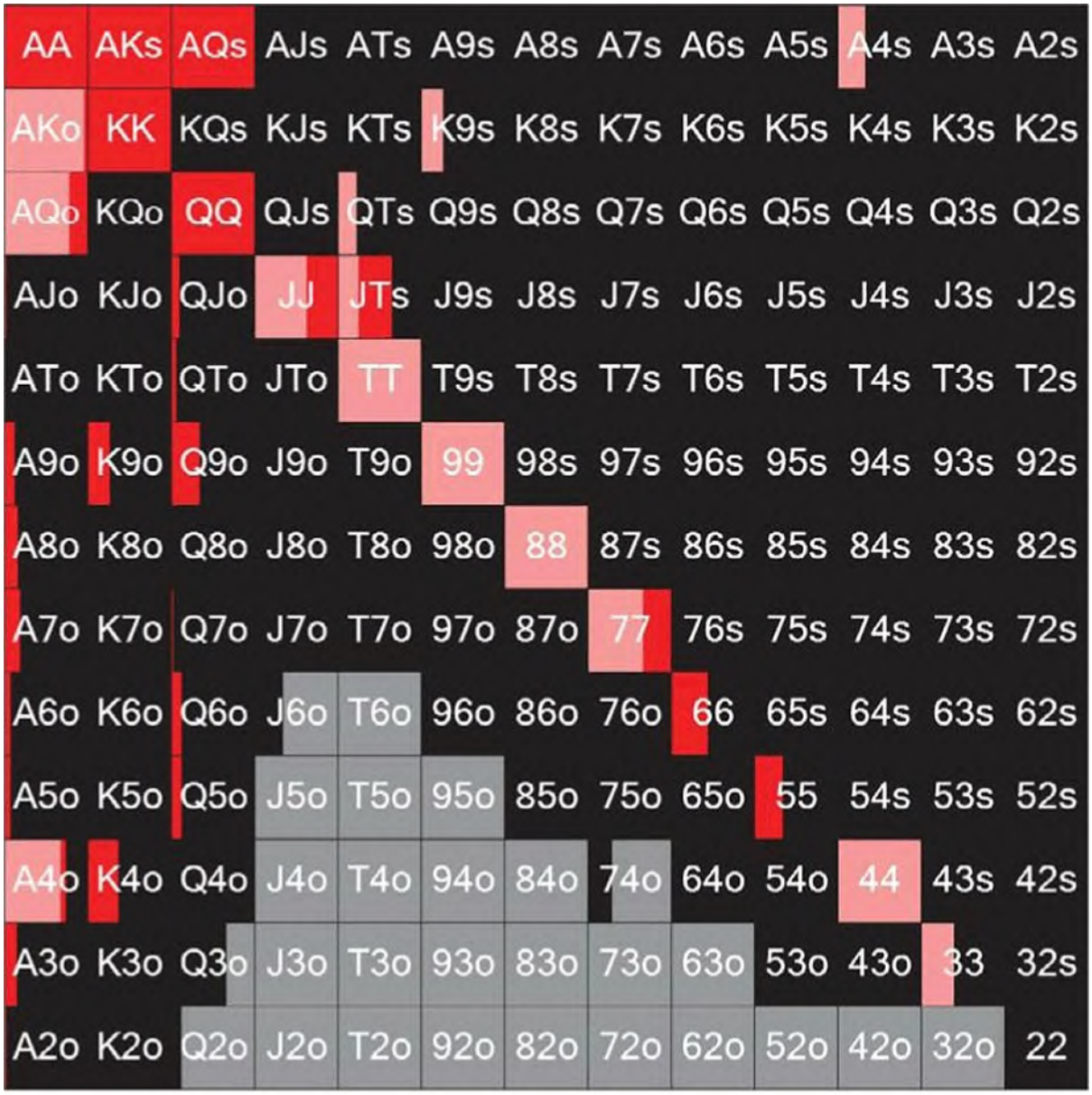
Hand Range 160: BB vs BN 4-bet (25bb) • Call 56.1% / • Fold 43.9%



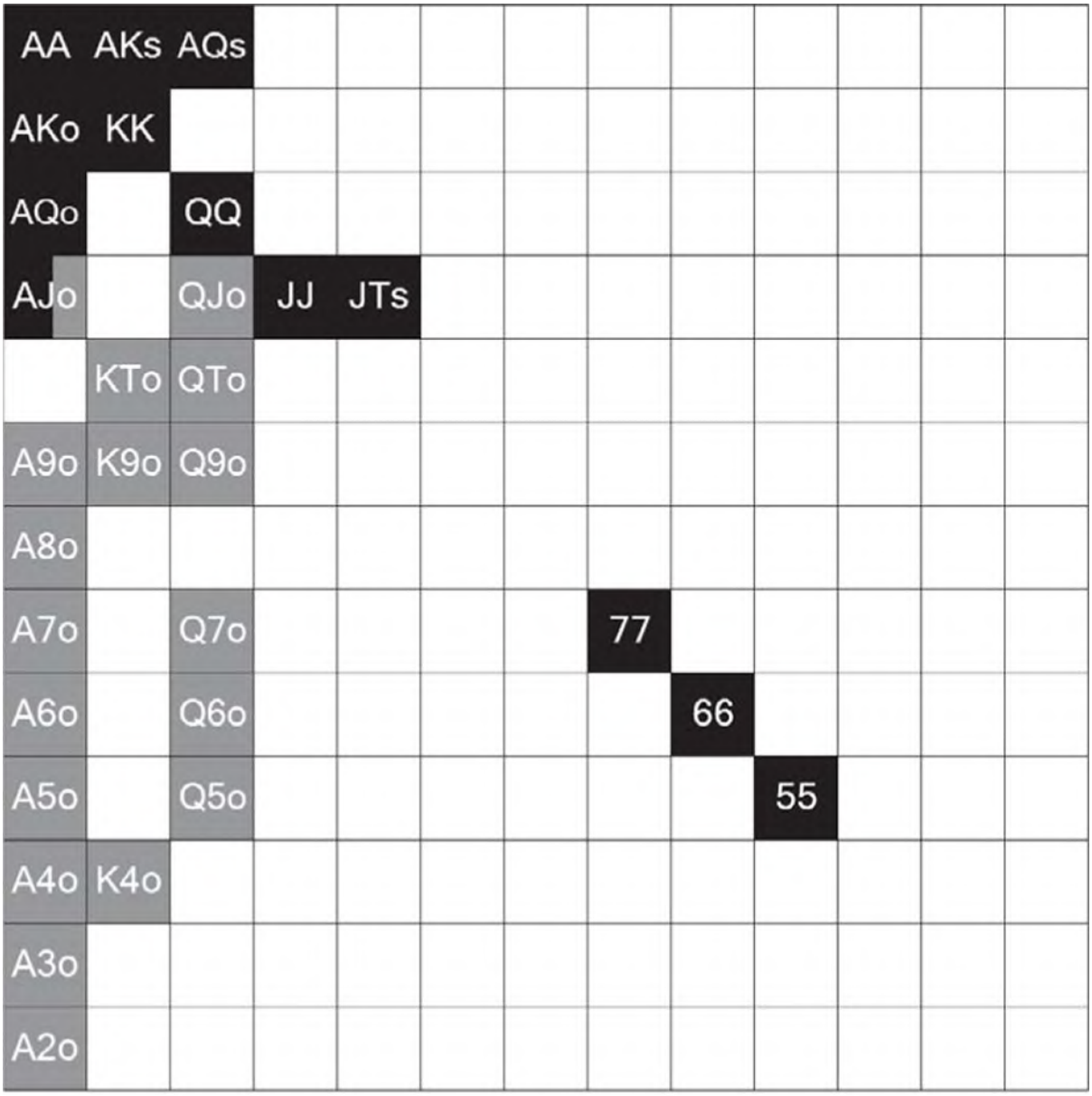
Hand Range 161: BB vs CO (25bb) • All-in 8.8% / • 3-bet 5.5% / • Call 67.1% / • Fold 18.6%



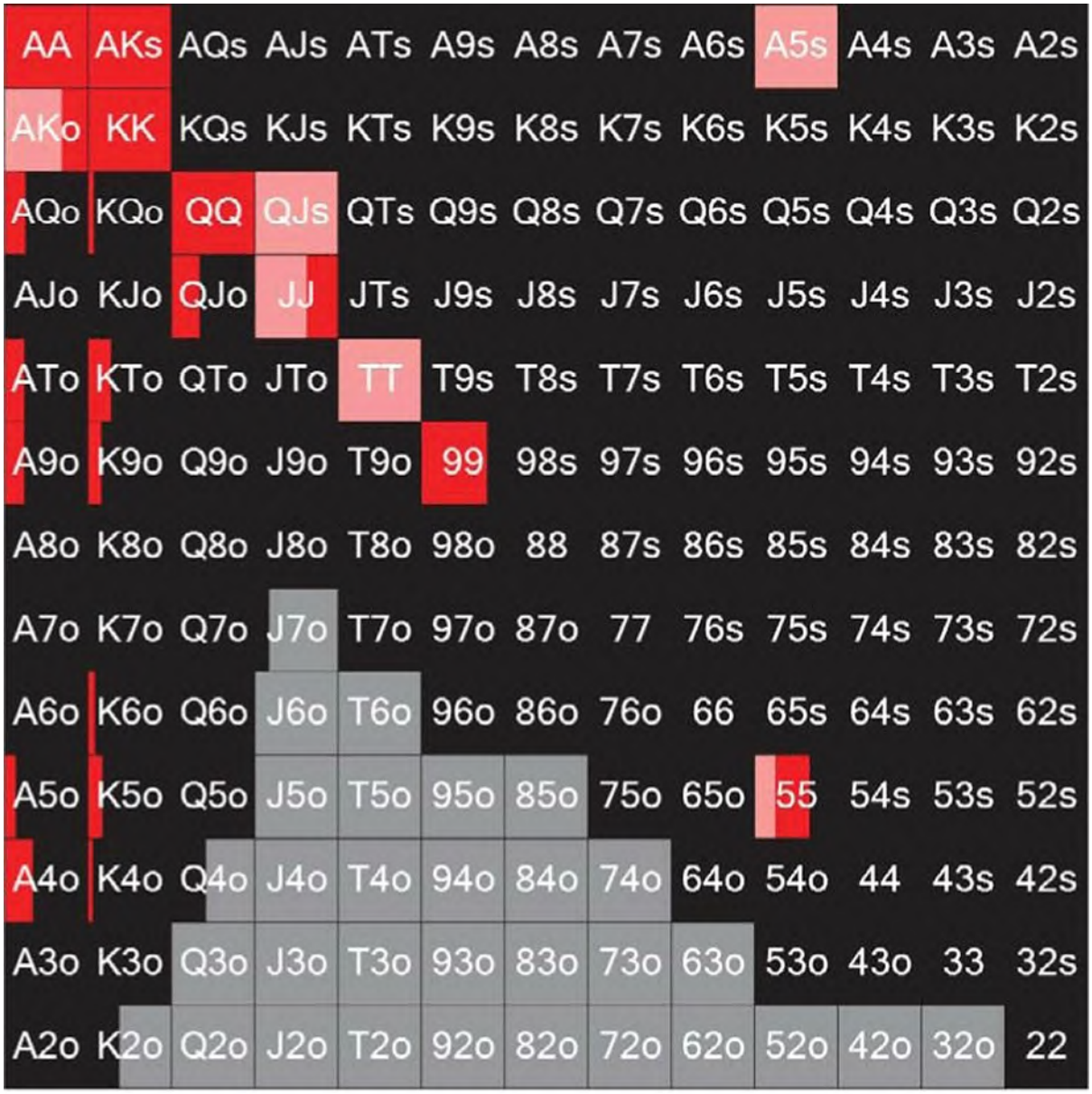
Hand Range 162: BB vs CO 4-bet (25bb) • Call 55.9% / • Fold 44.1%



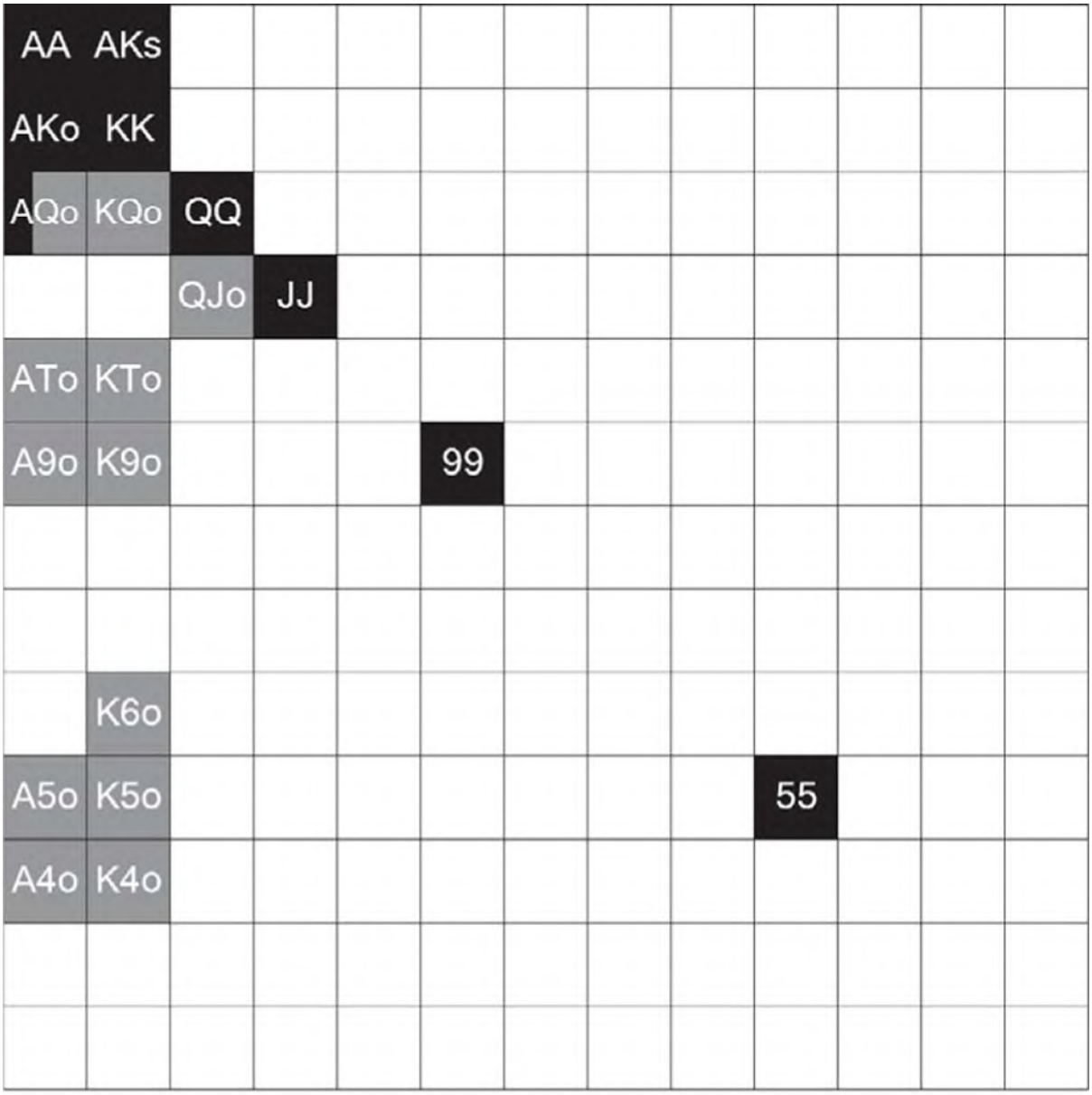
Hand Range 163: BB vs LJ (25bb) • All-in 5.1% / • 3-bet 5% / • Call 66.8% / • Fold 23.2%



Hand Range 164: BB vs LJ 4-bet (25bb) • Call 60.5% / • Fold 39.5%



Hand Range 165: BB vs UTG (25bb) • All-in 2.1% / • 3-bet 4.7% / • Call 66% / • Fold 27.2%



Hand Range 166: BB vs UTG 4-bet (25bb) • Call 57.8% / • Fold 42.2%

Defending the BB Versus IP (40bb)

BB vs	All-in	3-bet	Call	Fold
BN	3.00%	14.10%	58.60%	24.20%
CO	1.30%	11.50%	56.20%	31.00%
HJ	0.70%	8.70%	54.90%	35.70%
LJ	0.20%	7.80%	54.20%	37.80%
UTG+2	0.00%	7.90%	50.50%	41.60%
UTG+1	0.00%	6.90%	48.80%	44.30%
UTG	0.00%	5.80%	49.10%	45.00%
Average	0.74%	8.96%	53.19%	37.09%

Table 61: BB Action Frequencies (40bb)

With 40bb, the BB is now too deep to 3-bet all-in against most positions. In fact, the earlier the opener's position, the less often the BB can rejam all-in due to the lack of pre-flop fold equity vs narrow ranges.

The folding frequency also increases drastically as Villain's range gets stronger, from 24.2% vs the BN to 45% vs UTG.

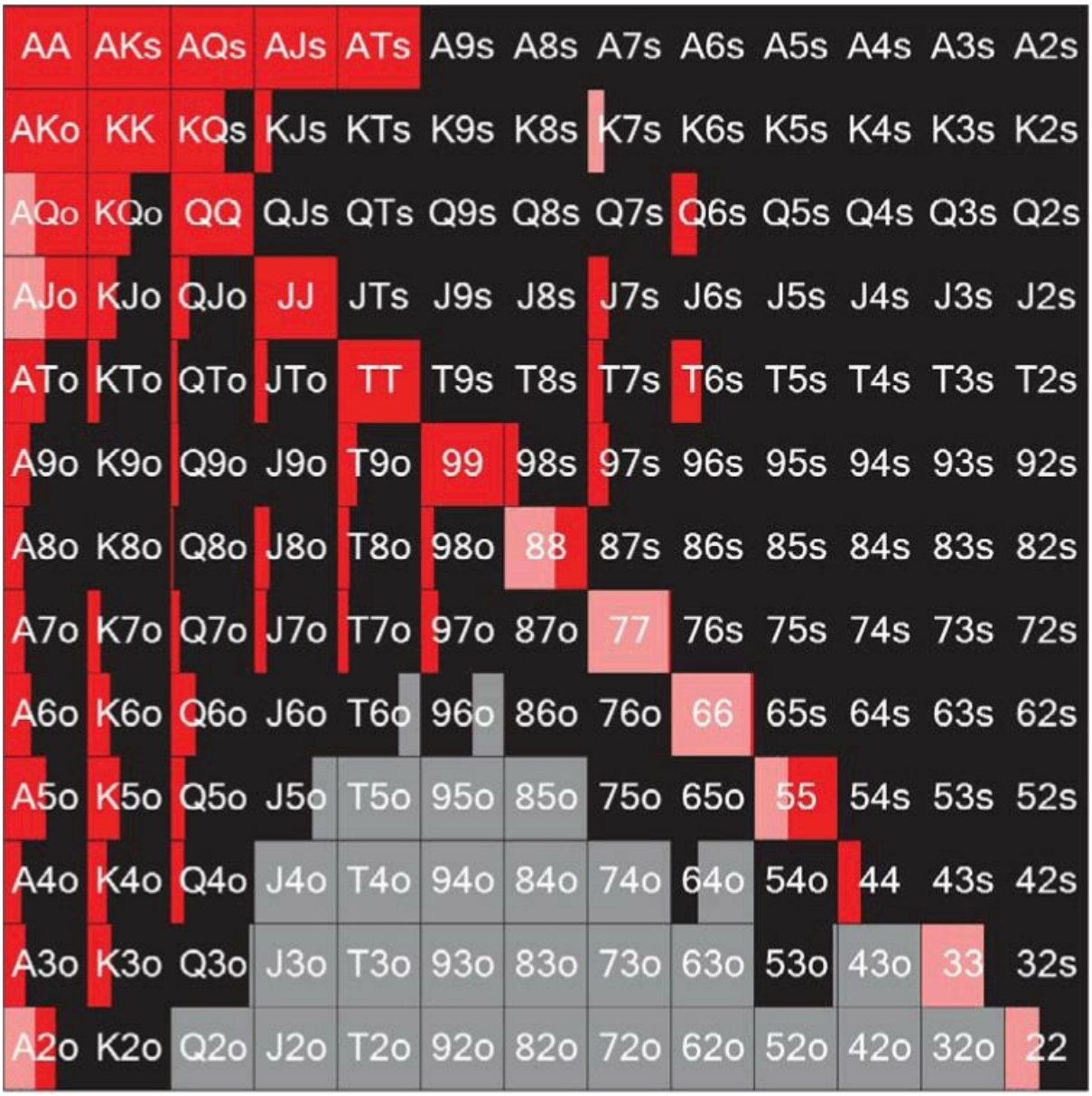
> *Many otherwise good players make the mistake of assuming they can profitably defend their big blind with any two cards vs EP opens because they view themselves better players than their opponents. The line of thinking goes something like this: "I can defend this trashy hand because my opponent's range is well defined and I can outplay him post-flop."*

The problem with this logic is that, even if it is true, equity and equity realization matter. Calling from out of position with too many hands vs tight ranges in high SPR situations is not a good combination. Most of the time, the reg in the BB will end up in difficult spots where they have to make tough call downs. Or, as I've seen many times, the BB will trash a decent stack with a silly hand trying to bluff their opponent off a big hand simply because the flop "hits" them more often than the Villain.

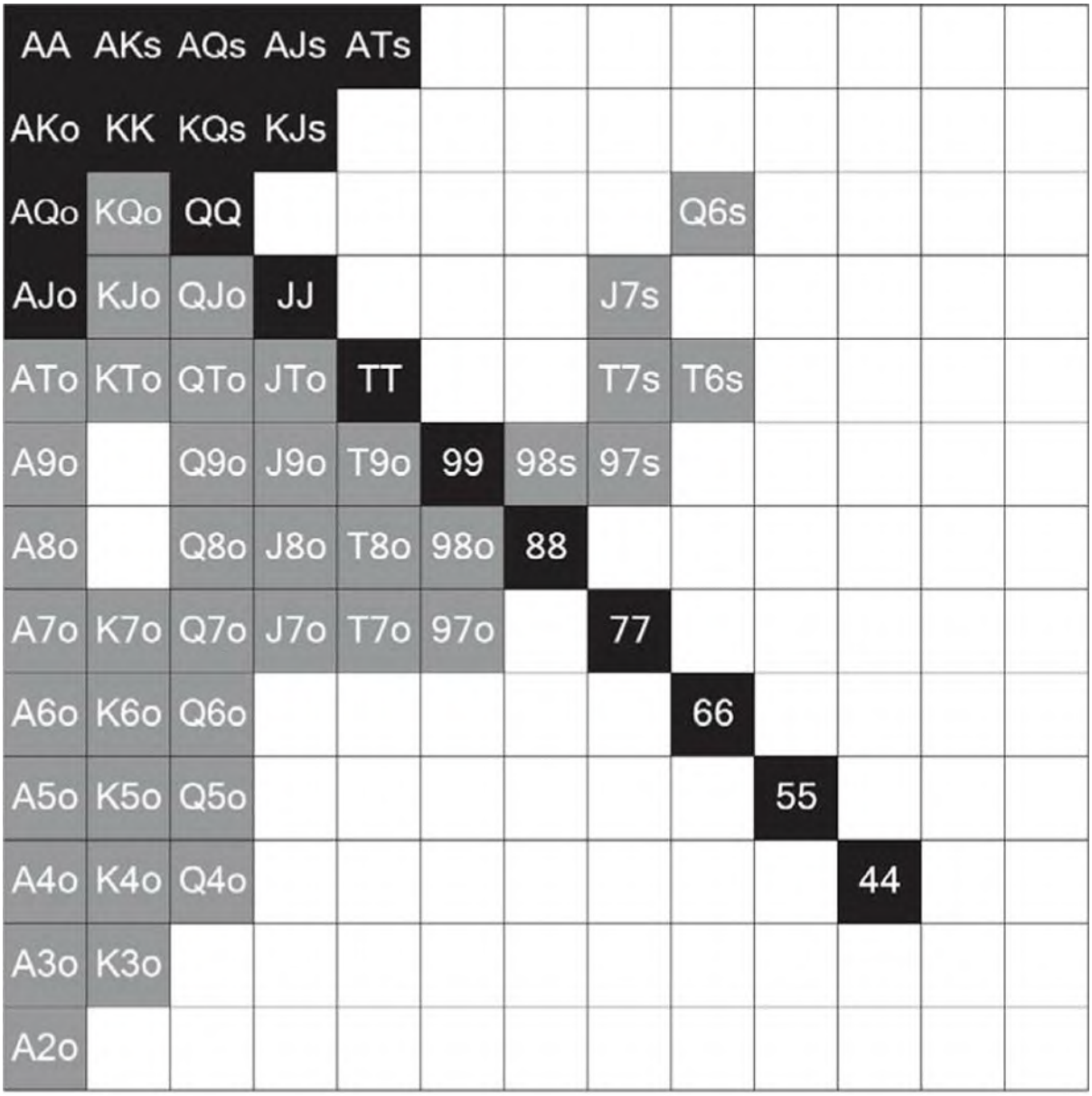
> *Against a non-all-in polarized range from an early position player, you should defend tighter and should use better hands as bluffs, while keeping your 3-betting frequency low.*

For example, if we compare the BB 3-betting ranges, it is very clear how the value range shrinks from 99+, ATs+, and AJ+ vs the BN to TT+ and AK vs UTG. When the value range shrinks, the bluffing range must also shrink, to the point that bluffs vs BN are made with

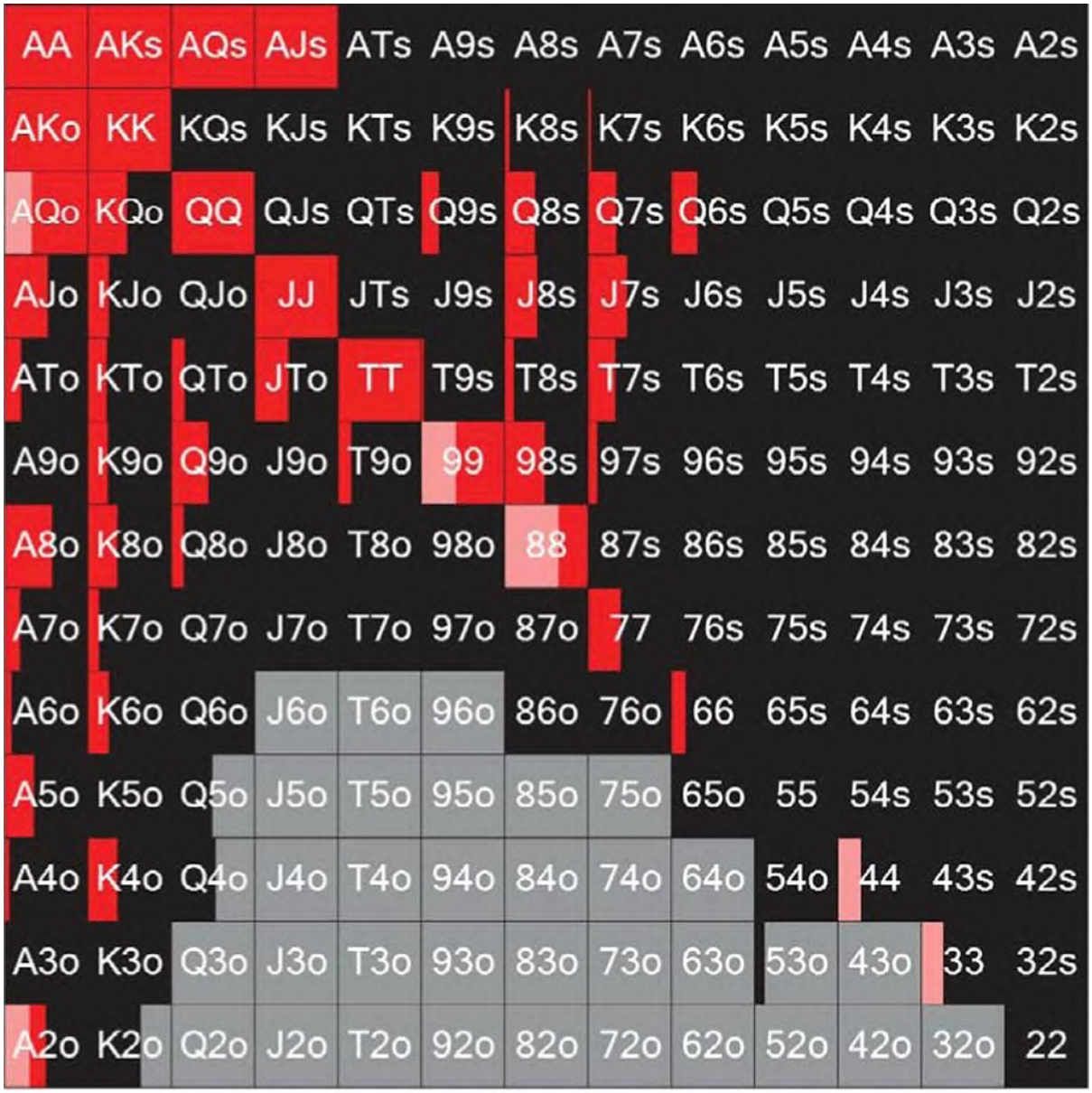
completely different hands than vs EP *(Hand Ranges 167-174)*.



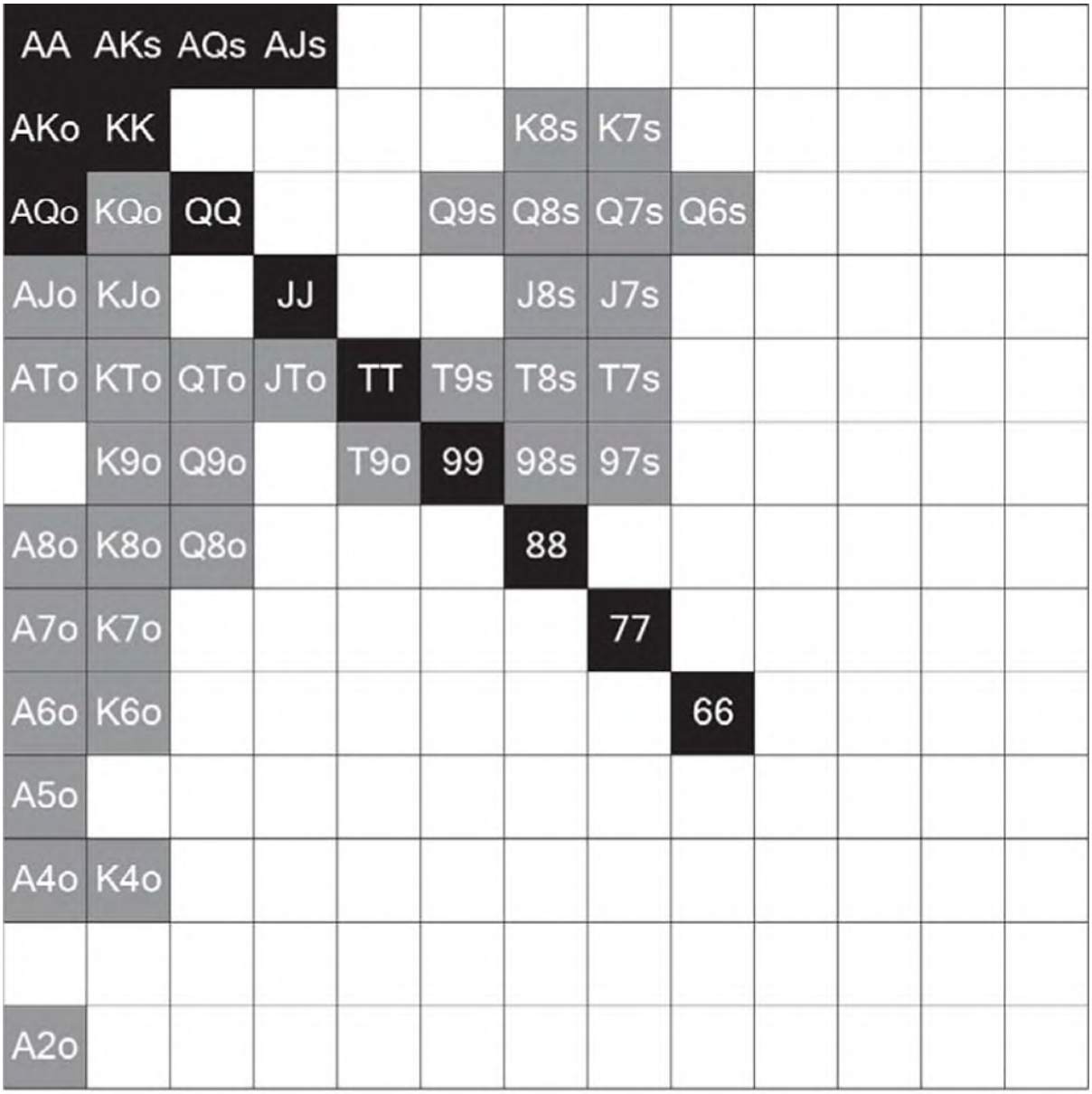
Hand Range 167: BB vs BN (40bb) • All-in 3% / • 3-bet 14.1% / • Call 58.6% / • Fold 24.2%



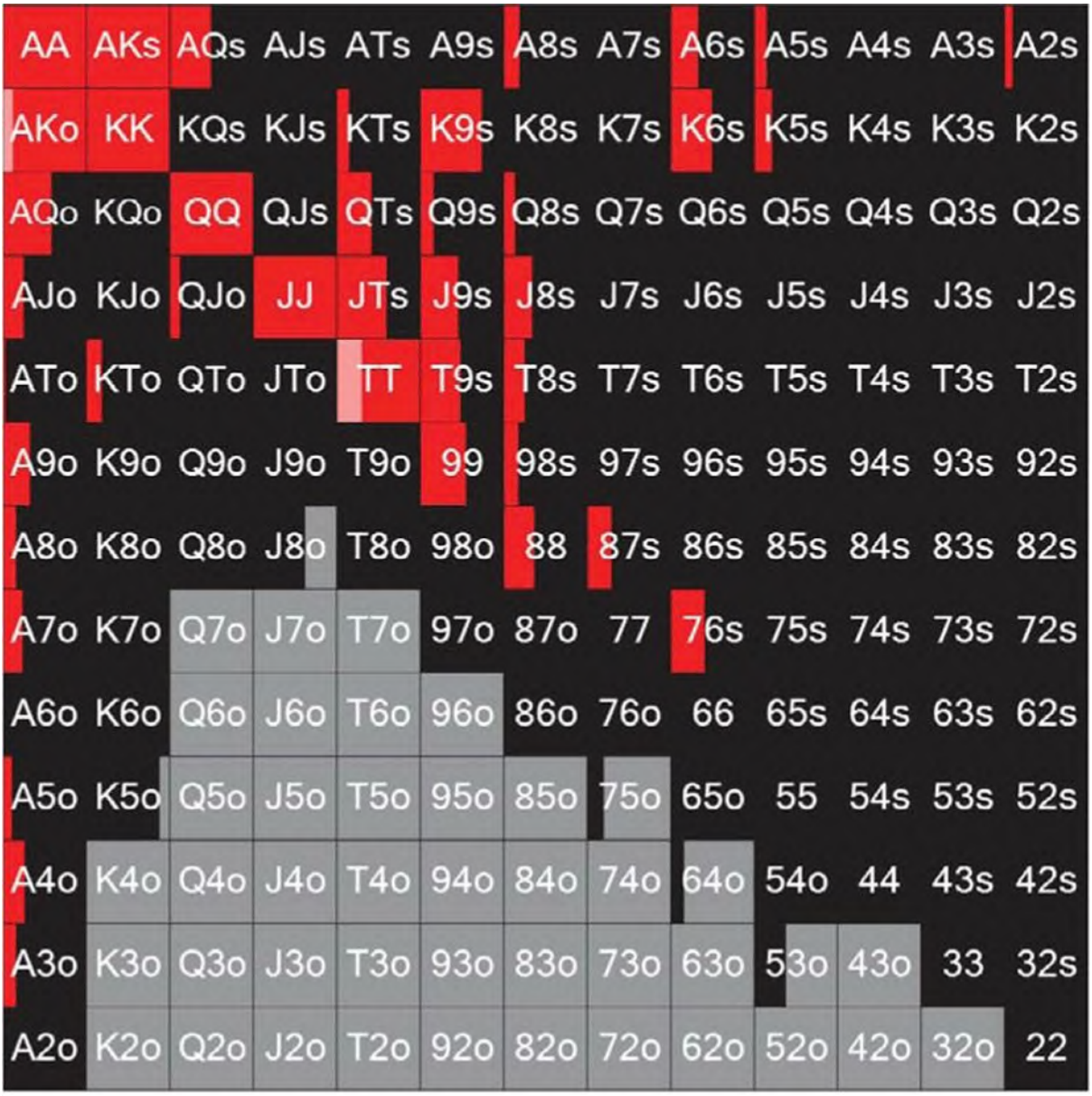
Hand Range 168: BB vs BN 4-bet (40bb) • Call 47.5% / • Fold 52.5%



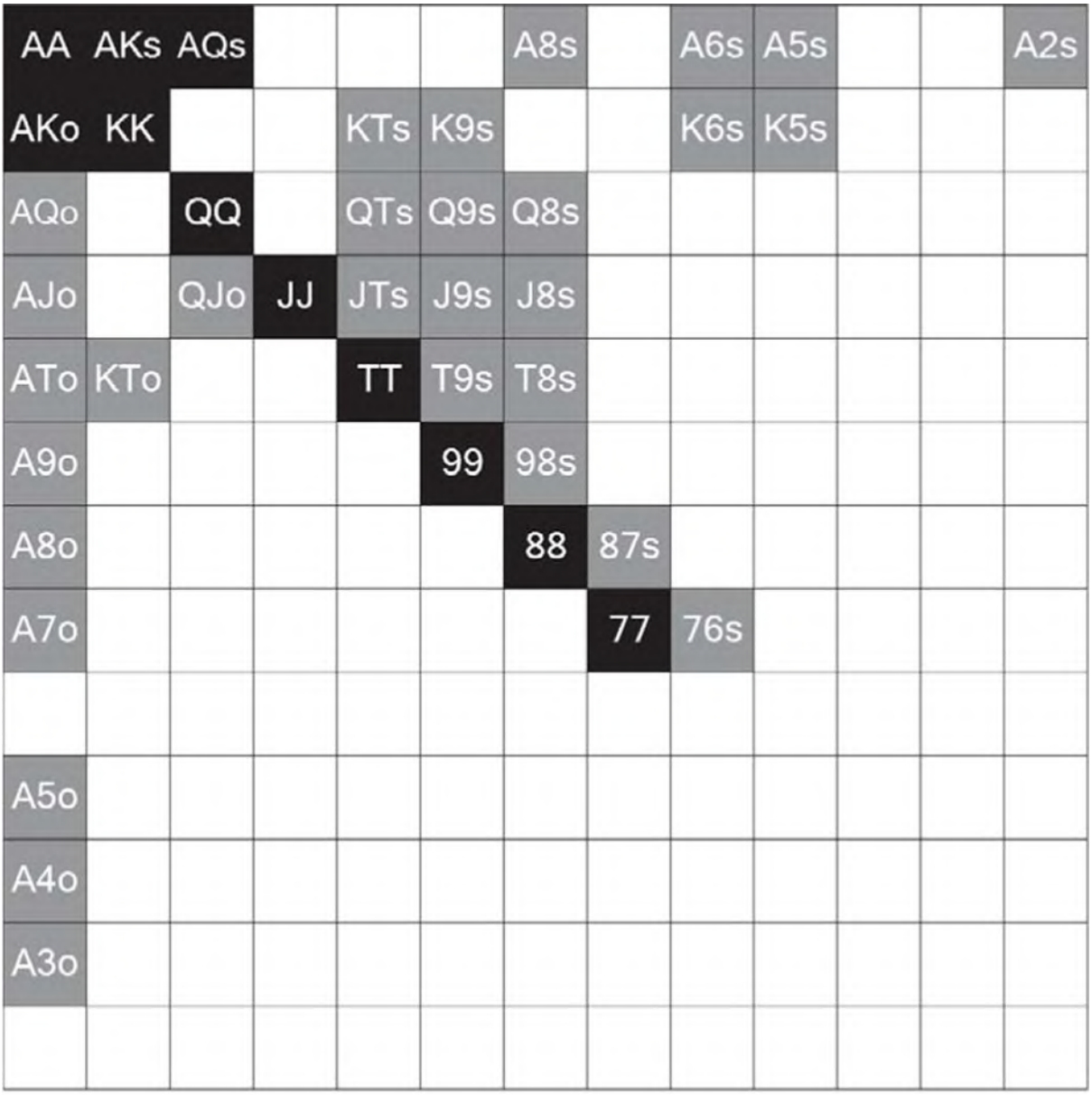
Hand Range 169: BB vs CO (40bb) • All-in 1.3% / • 3-bet 11.5% / • Call 56.2% / • Fold 31%



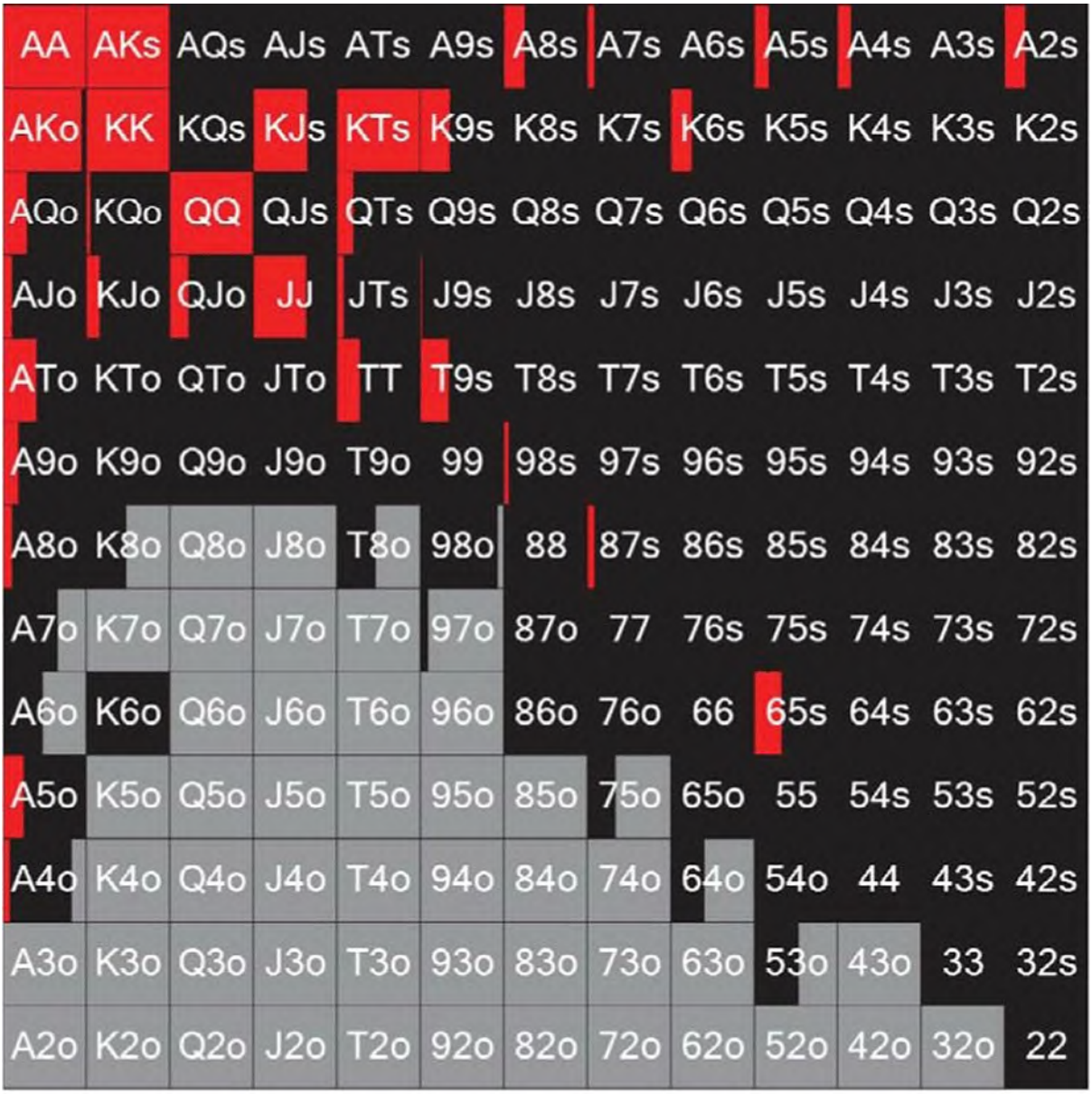
Hand Range 170: BB vs CO 4-bet (40bb) • Call 46.6% / • Fold 53.4%



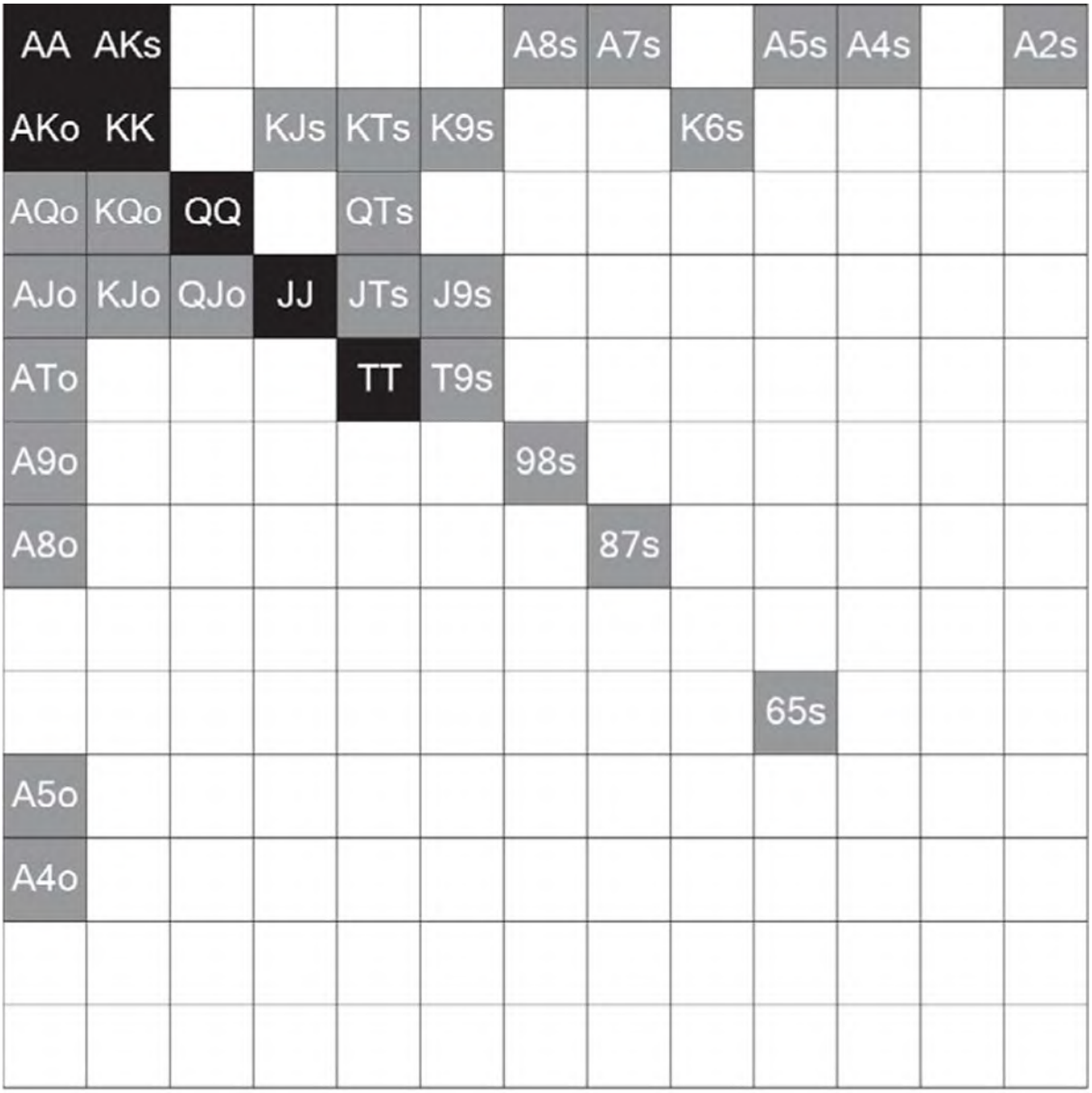
Hand Range 171: BB vs LJ (40bb) • All-in 0.2% / • 3-bet 7.8% / • Call 54.2% / • Fold 37.8%



Hand Range 172: BB vs LJ 4-bet (40bb) • Call 48.8% / • Fold 51.2%



Hand Range 173: BB vs UTG (40bb) • 3-bet 5.8% / • Call 49.1% / • Fold 45%



Hand Range 174: BB vs UTG 4-bet (40bb) • Call 50.1% / • Fold 49.9%

Defending the BB Versus IP (60bb)

BB vs	All-in	3-bet	Call	Fold
BN	16.80%	65.10%	18.10%	24.20%
CO	11.70%	63.10%	25.20%	31.00%
HJ	8.70%	58.40%	32.90%	35.70%
LJ	7.40%	56.50%	36.00%	37.80%
UTG+2	7.10%	52.40%	40.40%	41.60%
UTG+1	5.90%	50.30%	43.90%	44.30%
UTG	5.30%	50.60%	44.10%	45.00%
Average	8.99%	56.63%	34.37%	37.09%

Table 62: BB Action Frequencies (60bb)

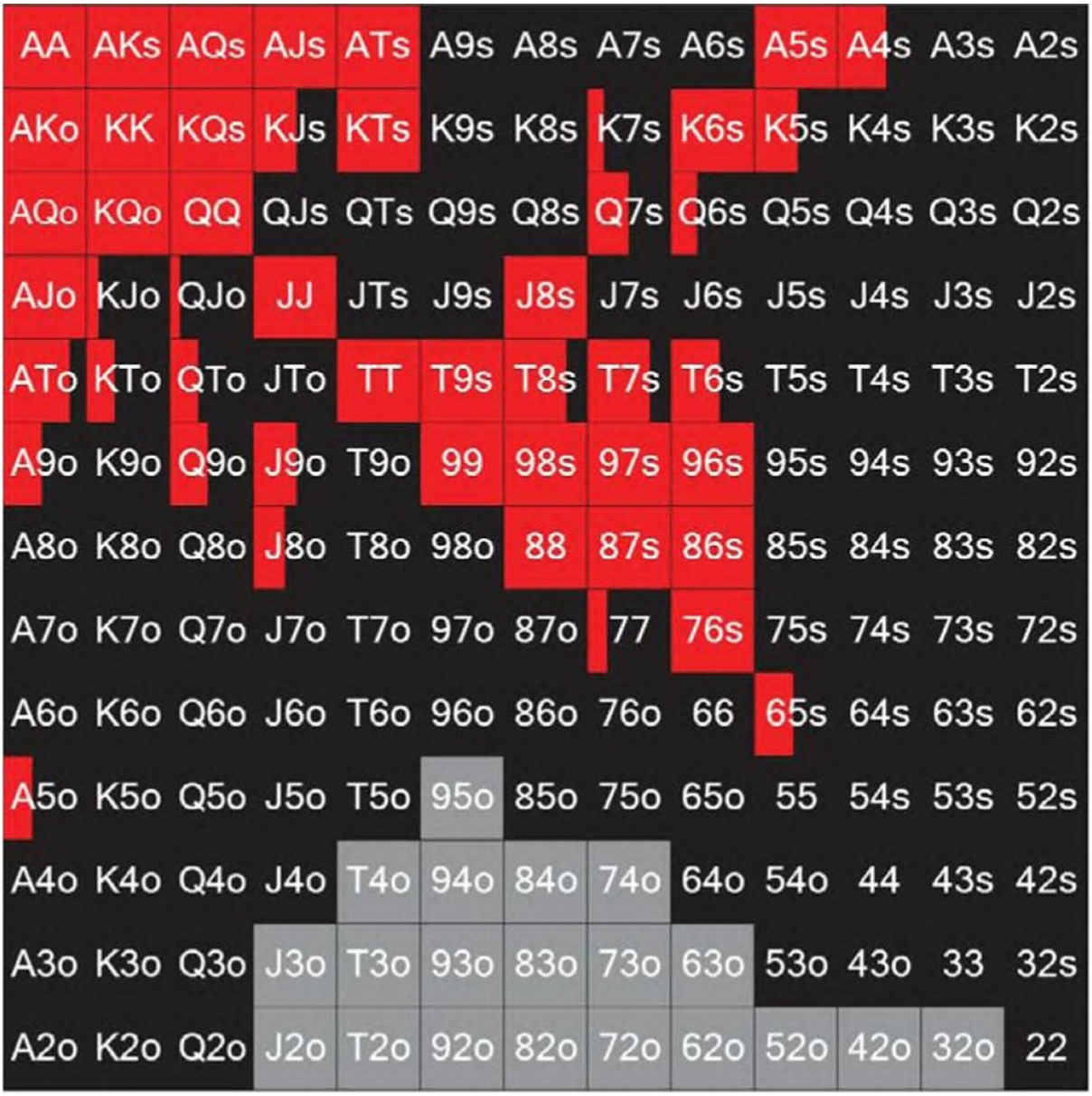
With 60bb, there is a slight increase in BB's defense frequency (65.63%) compared to 40bb (62.91%). This could be because some weaker hands now have better implied odds, allowing the BB to defend wider, or it could be a function of the way the simulations were designed.

The main weapon IP has to lower OOP EQR when stacks are deep is to overbet the pot.

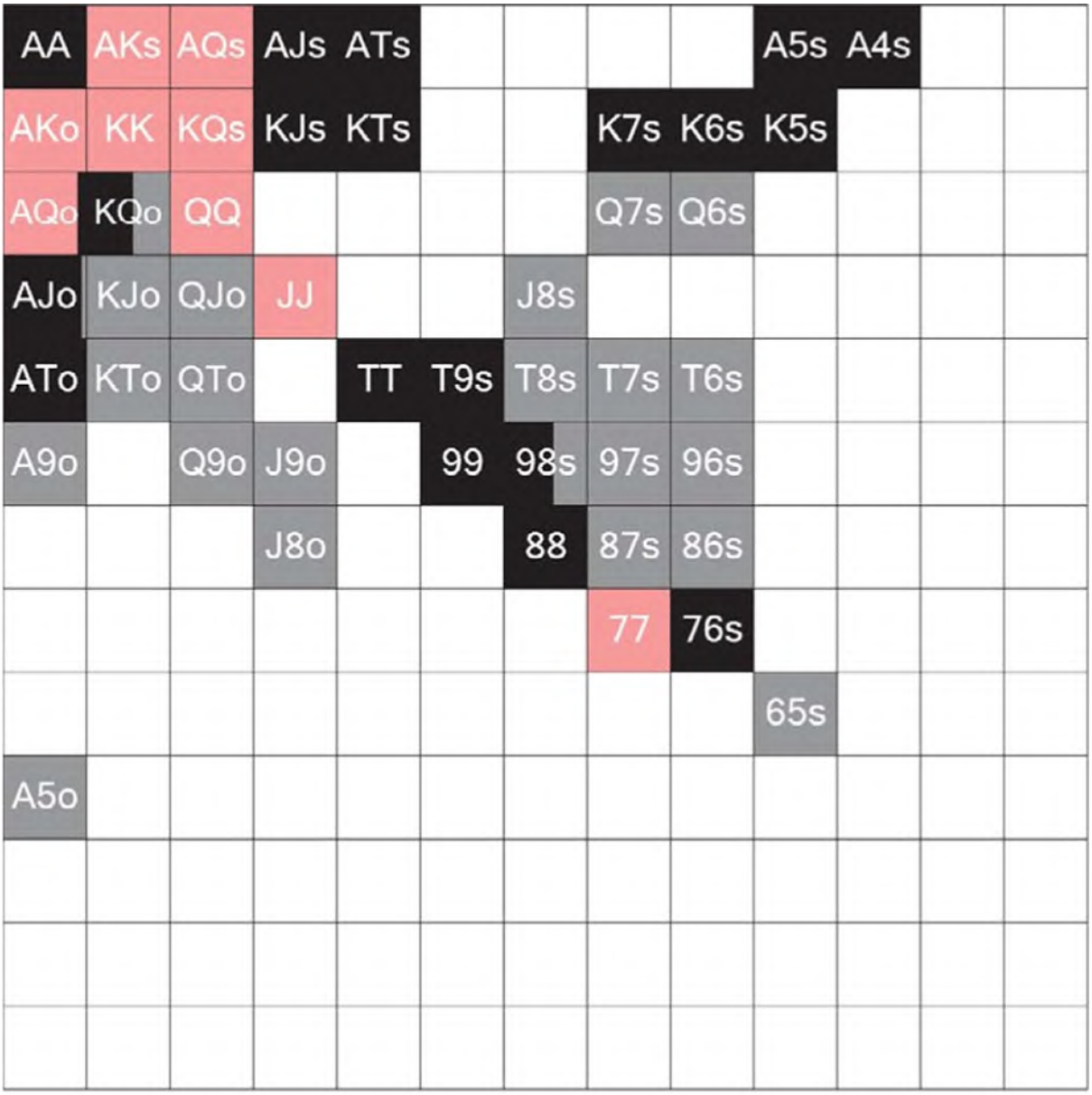
So, I would expect to see slightly lower BB defense frequencies in simulations where overbets are allowed. In the current game, players still do not use overbets nearly as often as they should in theory, so these BB defense frequencies will fare well in modern games. I would recommend cutting down the weaker hands vs really tough opponents who are capable of overbetting and applying a lot of post-flop pressure.

At 60bb, the BB 3-betting range is less polarized than it was at 40bb, including more suited hands with good post-flop playability. As demonstrated so far, the range changes as the opponent's range changes, going from 3-betting as wide as 16.80% vs the BN to only 5.3% vs UTG and also folding vs the BN's open 18.10% of the time and 44.10% vs UTG.

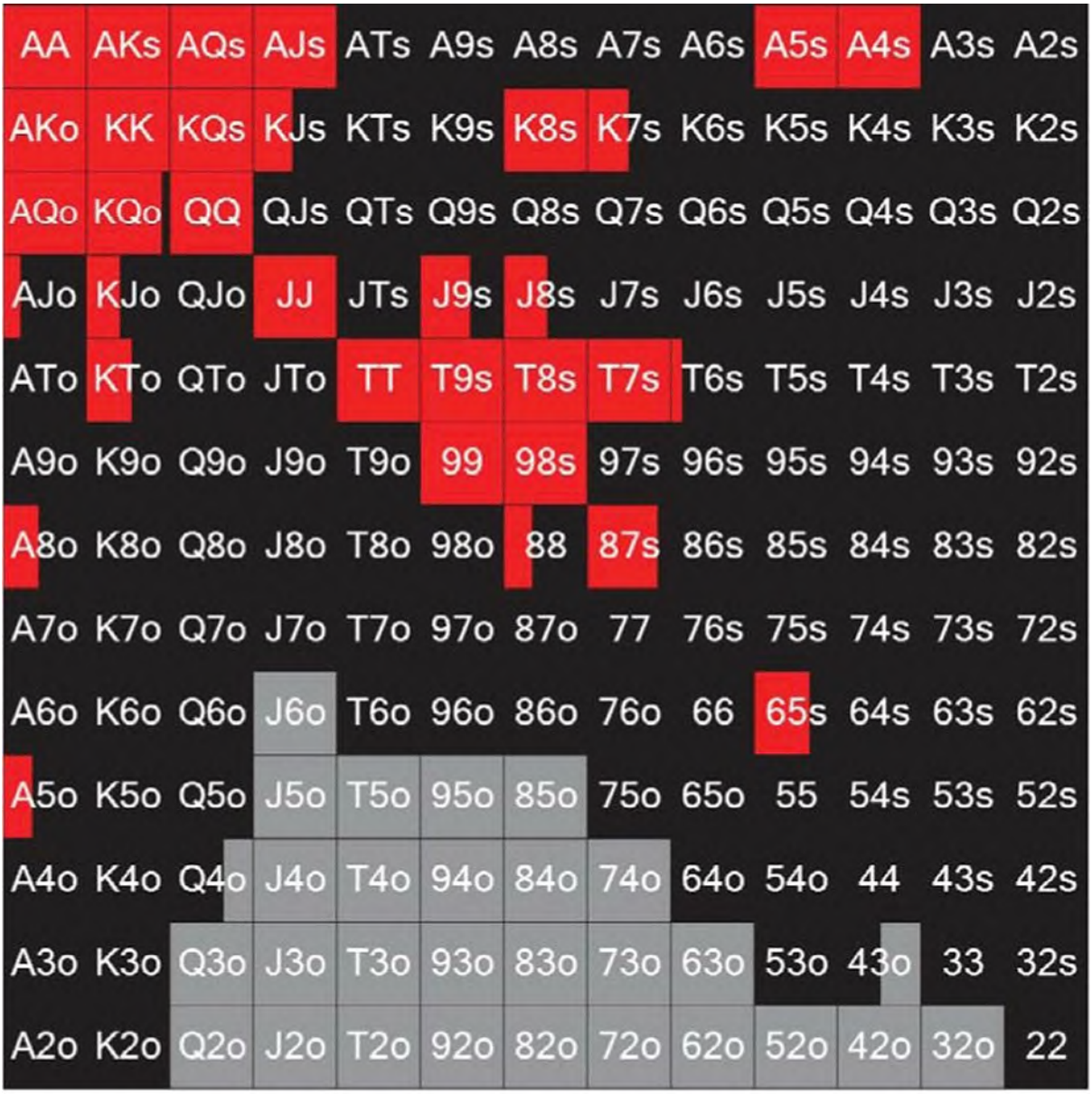
When facing 4-bets, the BB has a healthy flatting range vs LP, but could easily only 5-bet or fold vs EP *(Hand Ranges 175-182)*.



Hand Range 175: BB vs BN (60bb) • 3-bet 16.8% / • Call 65.1% / • Fold 18.10%

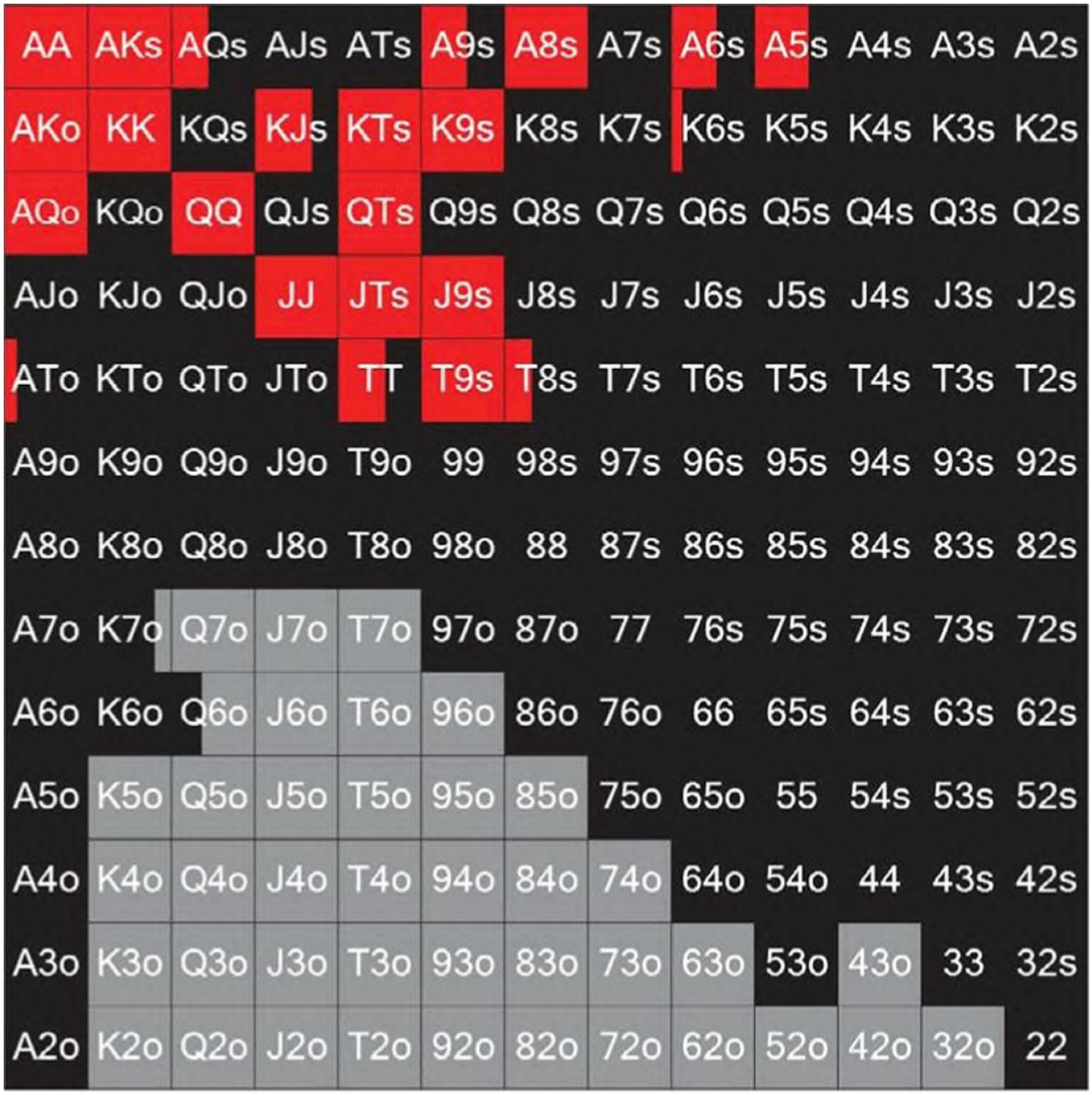


Hand Range 176: BB vs BN 4-bet (60bb) • All-in 24.2% / • Call 40.5% / • Fold 35.2%

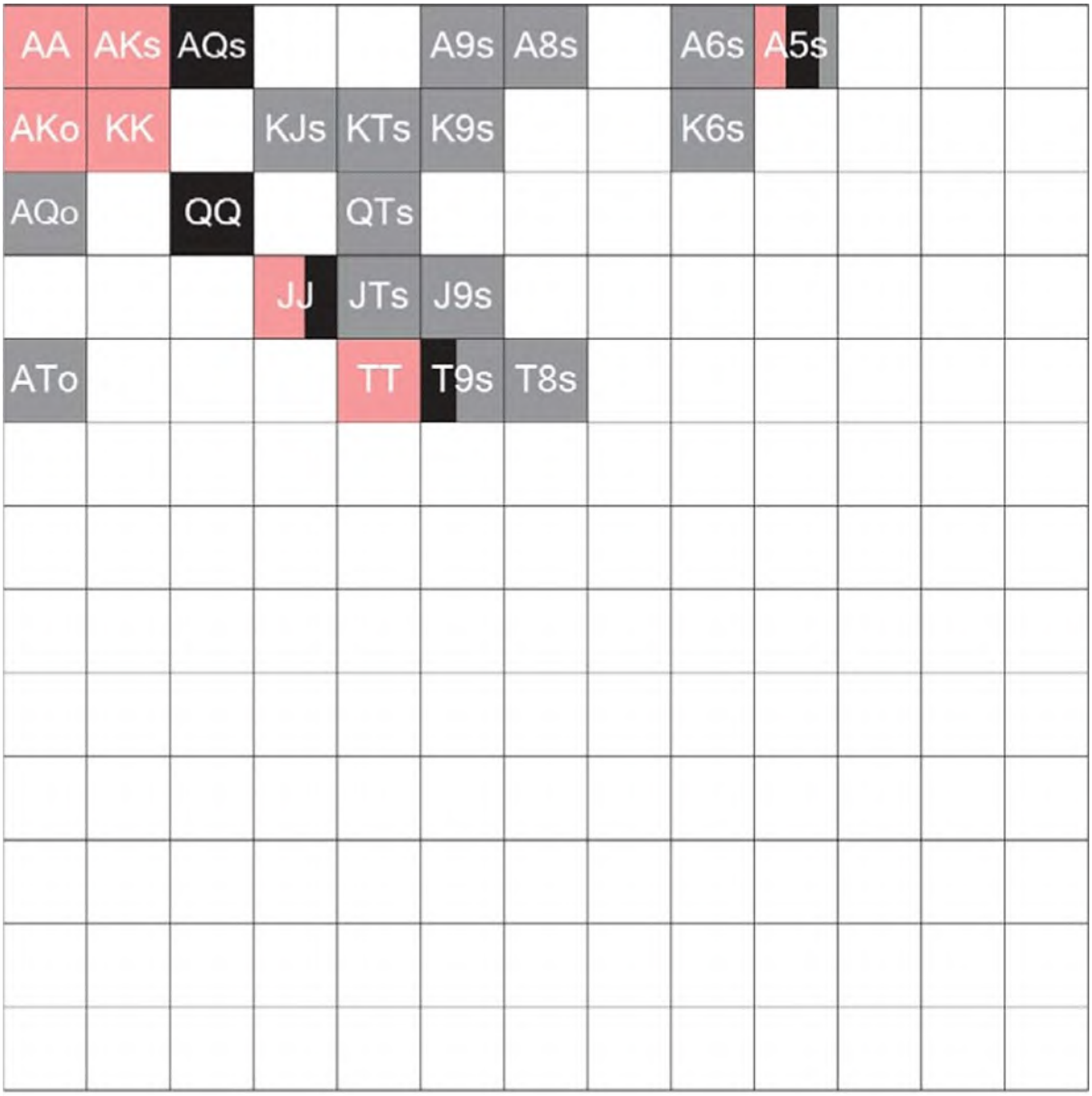


Hand Range 177: BB vs CO (60bb) • 3-bet 11.7% / • Call 63.1% / • Fold 25.20%

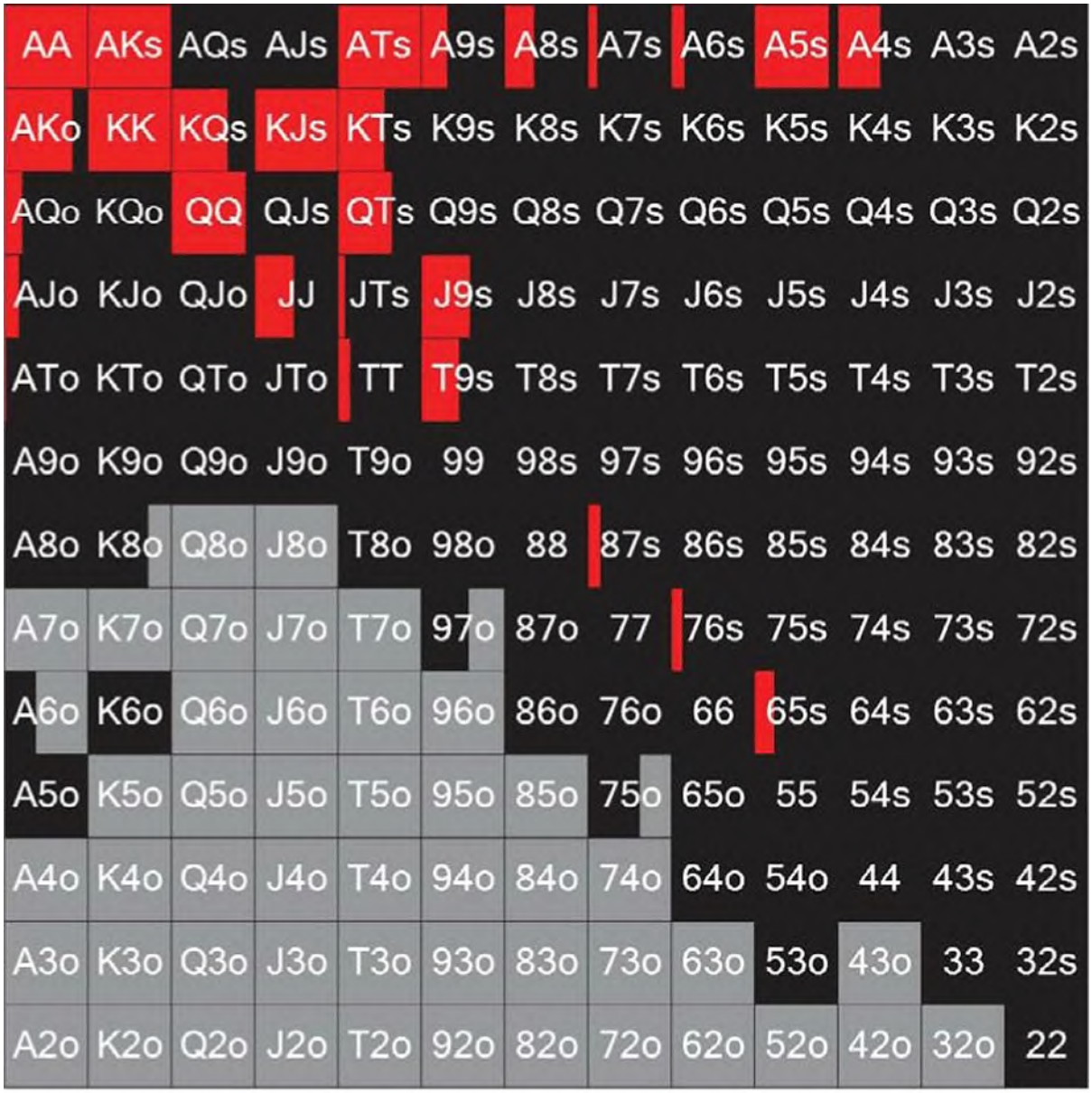
Hand Range 178: BB vs CO 4-bet (60bb) • All-in 27.9% / • Call 36.5% / • Fold 35.6%



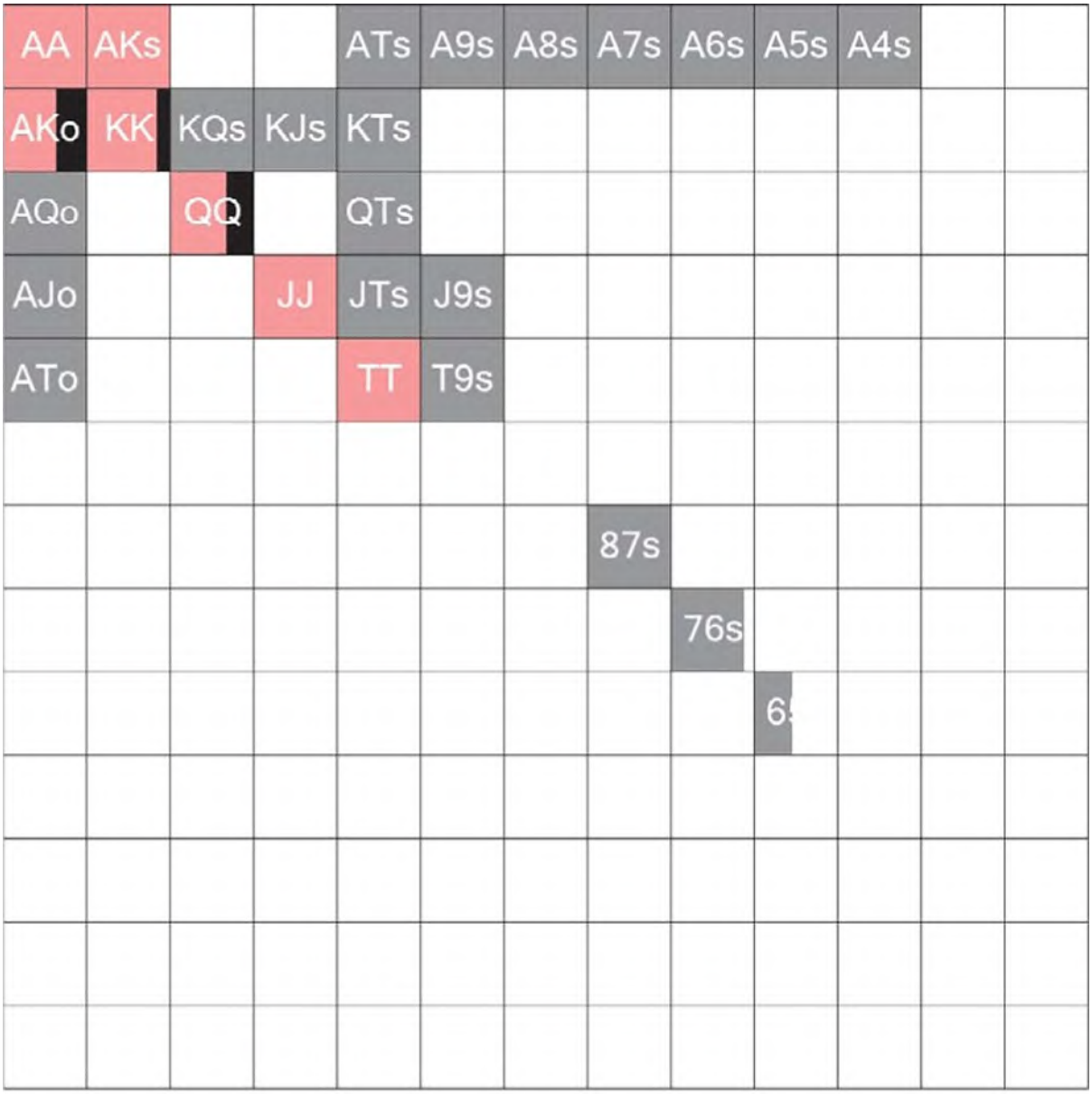
Hand Range 179: BB vs LJ (60bb) • 3-bet 7.4% / • Call 56.5% / • Fold 36%



Hand Range 180: BB vs LJ 4-bet (60bb) • All-in 36.6% / • Call 13.1% / • Fold 50.4%



Hand Range 181: BB vs UTG (60bb) • 3-bet 5.3% / • Call 50.6% / • Fold 44.1%



Hand Range 182: BB vs UTG 4-bet (60bb) • All-in 40.3% / • Call 6.1% / • Fold 53.7%

Defending the Small Blind

Defending the SB (15bb)

On average, the SB should VPIP 22% hands at 15bb, playing 3-bet or jam vs LP opens, rejamming as much as 28.2% against the BN and 22.5% against the CO. Against middle position and earlier, the opener's range starts to become strong enough such that the SB rejams won't get

enough folds, so the solver chooses to start calling some hands that are no longer profitable rejams but are profitable calls. So, the 3-betting frequency decreases while the flatting frequency increases as the opener's range gets stronger.

SB vs	All-in	Call	Fold
BN	28.20%	0.00%	71.80%
CO	22.50%	0.10%	77.40%
HJ	17.70%	1.90%	80.40%
LJ	14.70%	5.40%	79.90%
UTG+2	11.90%	8.50%	79.60%
UTG+1	10.30%	10.70%	79.00%
UTG	9.40%	11.60%	79.00%
Average	16.39%	5.46%	78.16%

Table 63: SB Action Frequencies (15bb)

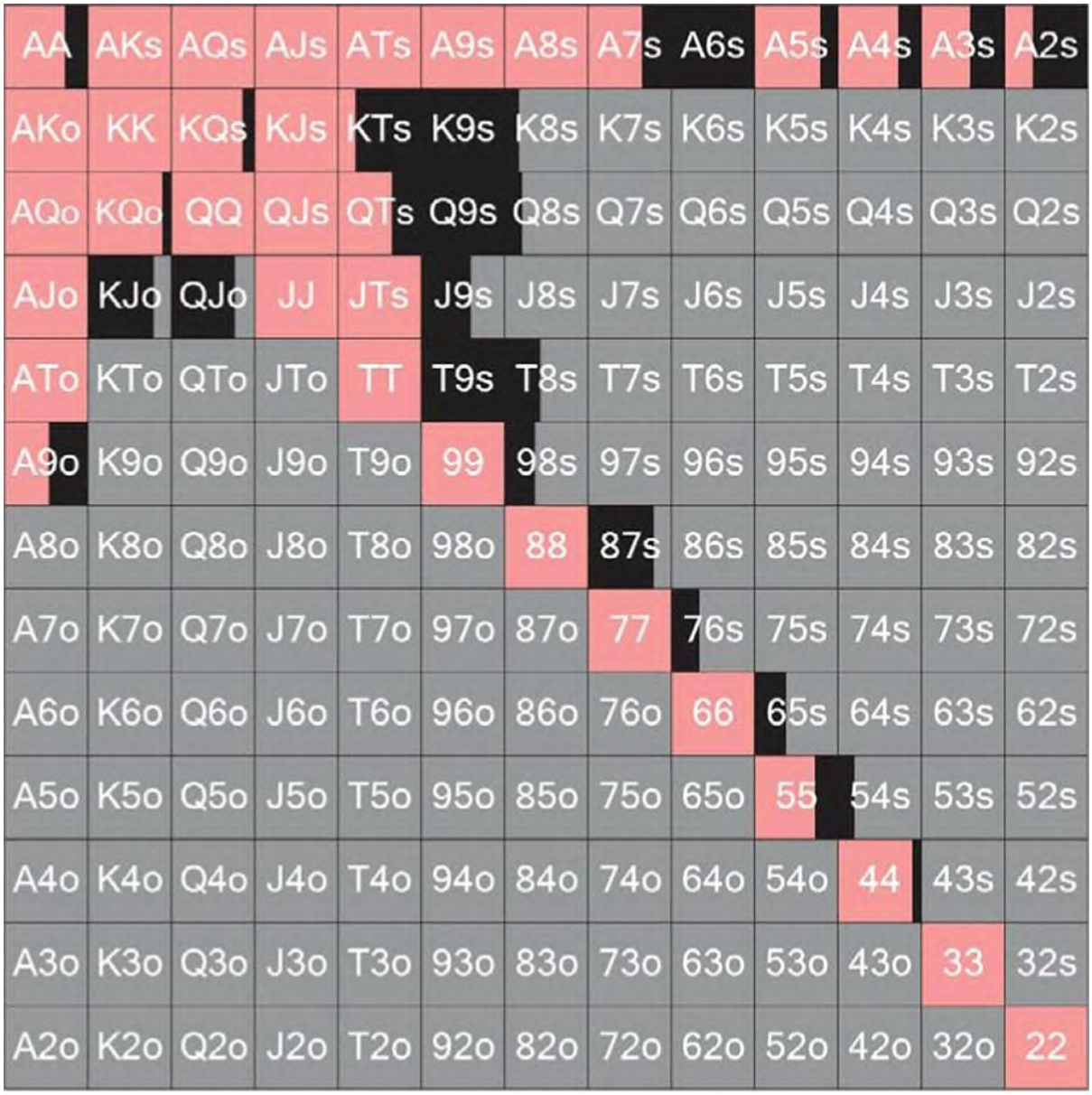
Because the BB will frequently call once the SB calls, hands such as suited connectors, small suited Ax, and broadway hands make great calls vs the earlier positions because they retain their equity well in multi-way pots. It's interesting to notice how AA gets slowplayed by the SB 25-33% of the time *(Hand Ranges 183-186)*.

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

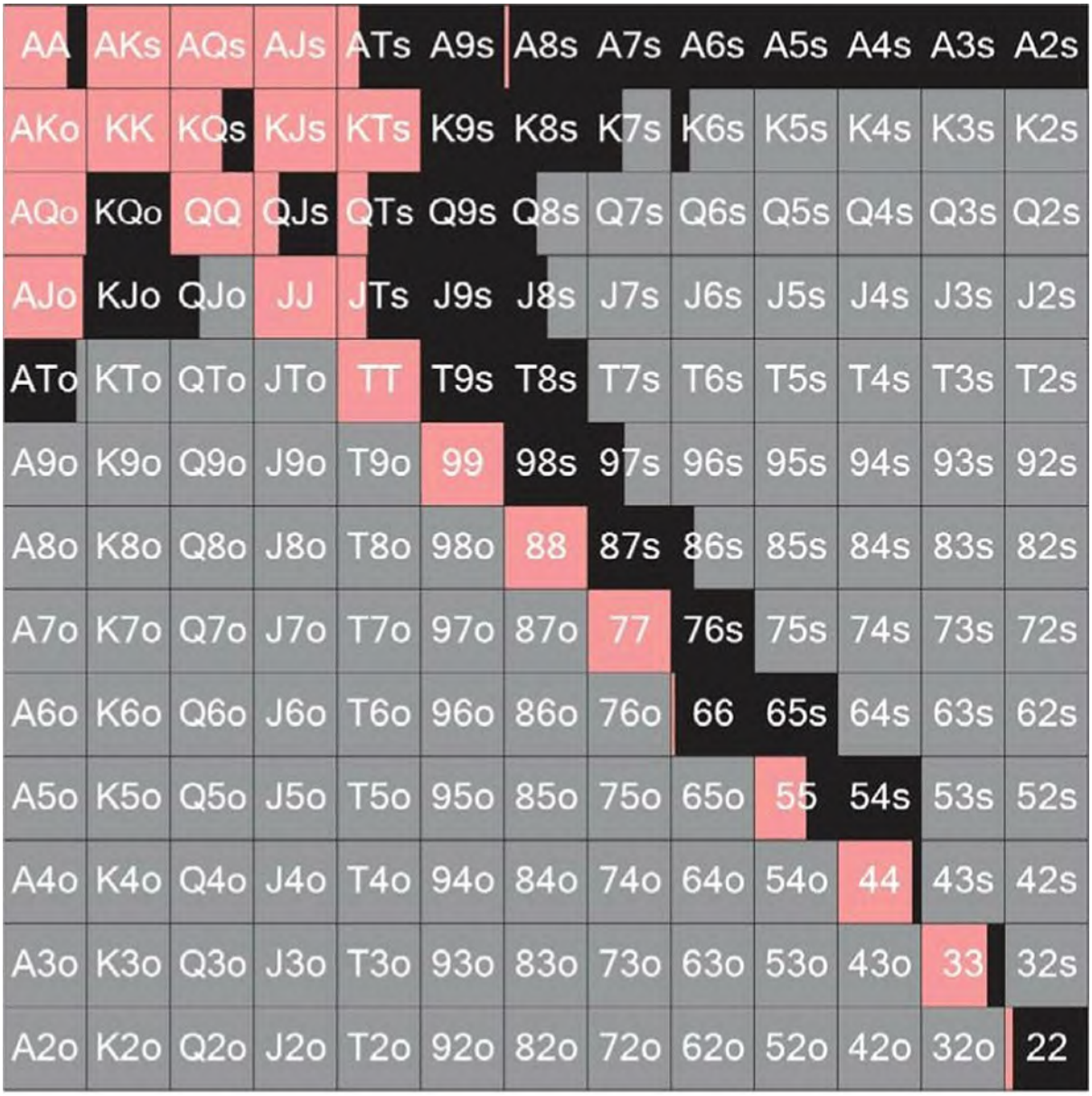
Hand Range 183: SB vs BN (15bb) • All-in 28.2% / • Call 0.0% / • Fold 71.8%

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

Hand Range 184: SB vs CO (15bb) • All-in 22.5% / • Call 0.1% / • Fold 77.4%



Hand Range 185: SB vs LJ (15bb) • All-in 14.7% / • Call 5.4% / • Fold 79.9%



Hand Range 186: SB vs UTG (15bb) • All-in 9.4% / • Call 11.6% / • Fold 79%

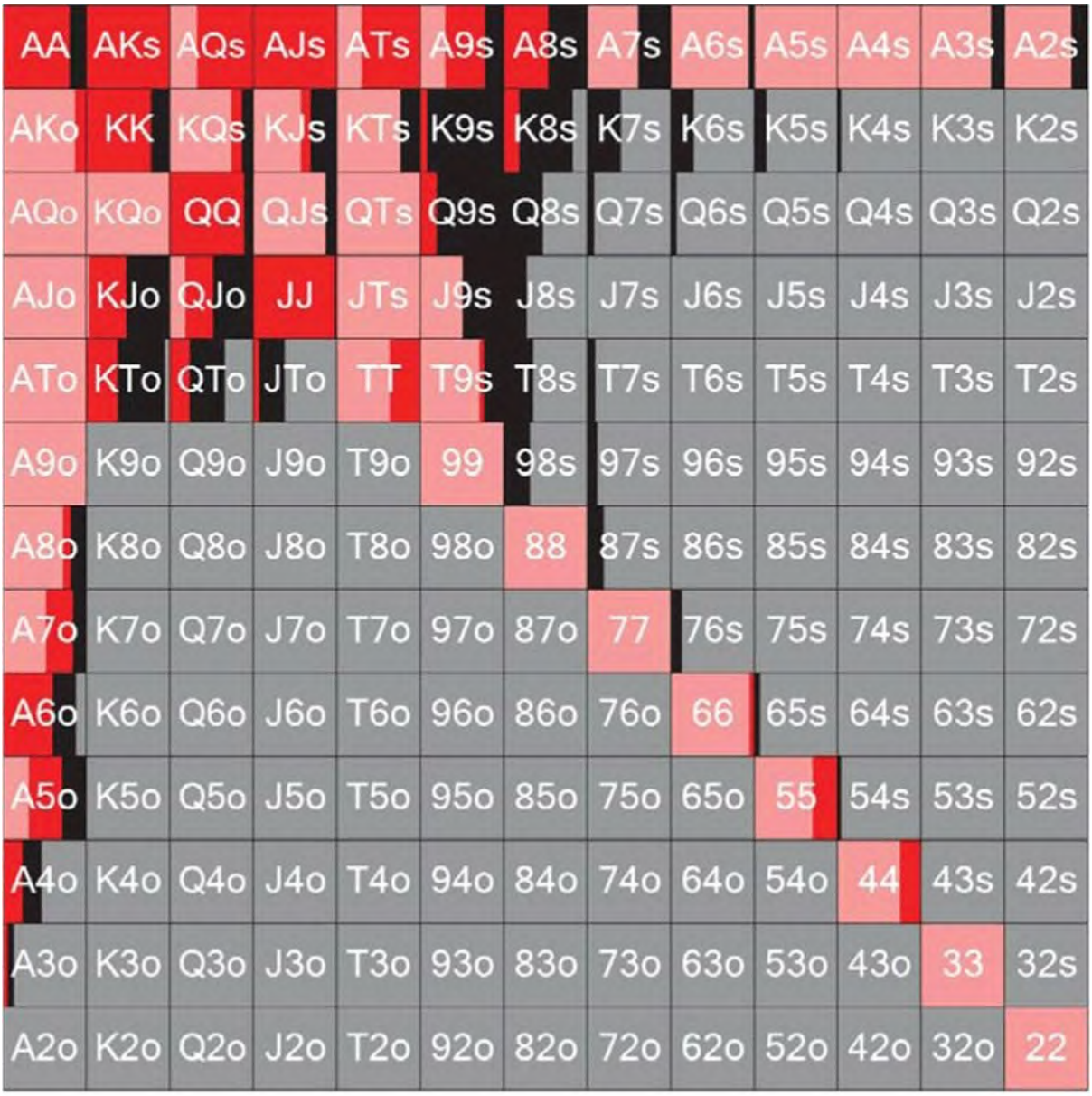
Defending the SB (25bb)

BB vs	All-in	3-bet	Call	Fold
BN	14.20%	6.50%	6.00%	73.20%
CO	11.20%	5.50%	9.90%	73.30%
HJ	8.10%	5.20%	12.70%	74.00%
LJ	6.40%	5.30%	12.60%	75.70%
UTG+2	5.00%	4.90%	13.90%	76.20%
UTG+1	3.80%	4.90%	14.00%	77.30%
UTG	3.50%	4.80%	14.20%	77.50%
Average	7.46%	5.30%	11.90%	75.31%

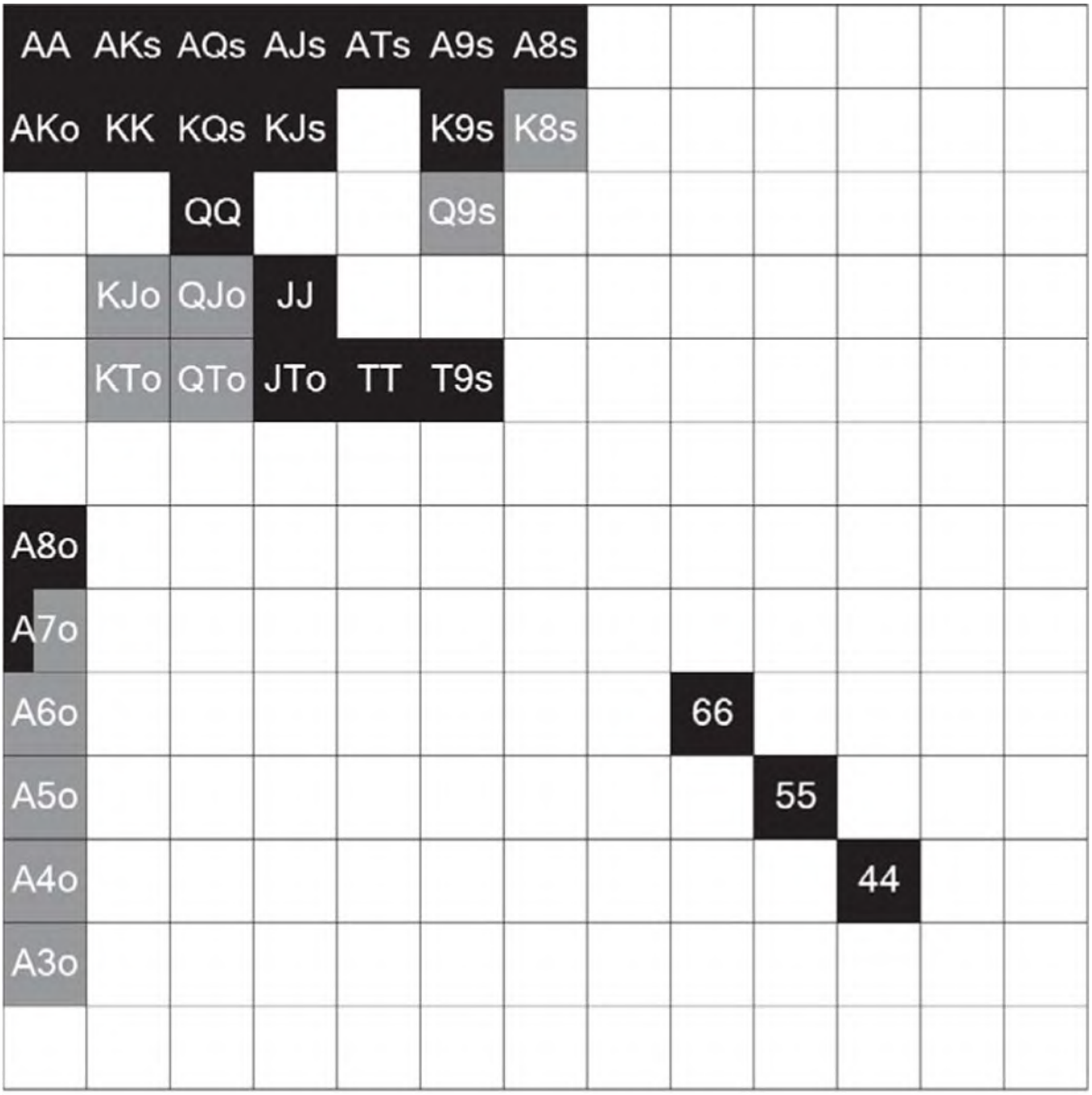
Table 64: SB Action Frequencies (25bb)

With 25bb, the same trends seen previously occur where the SB gets to VPIP less often as the opener's range gets stronger.

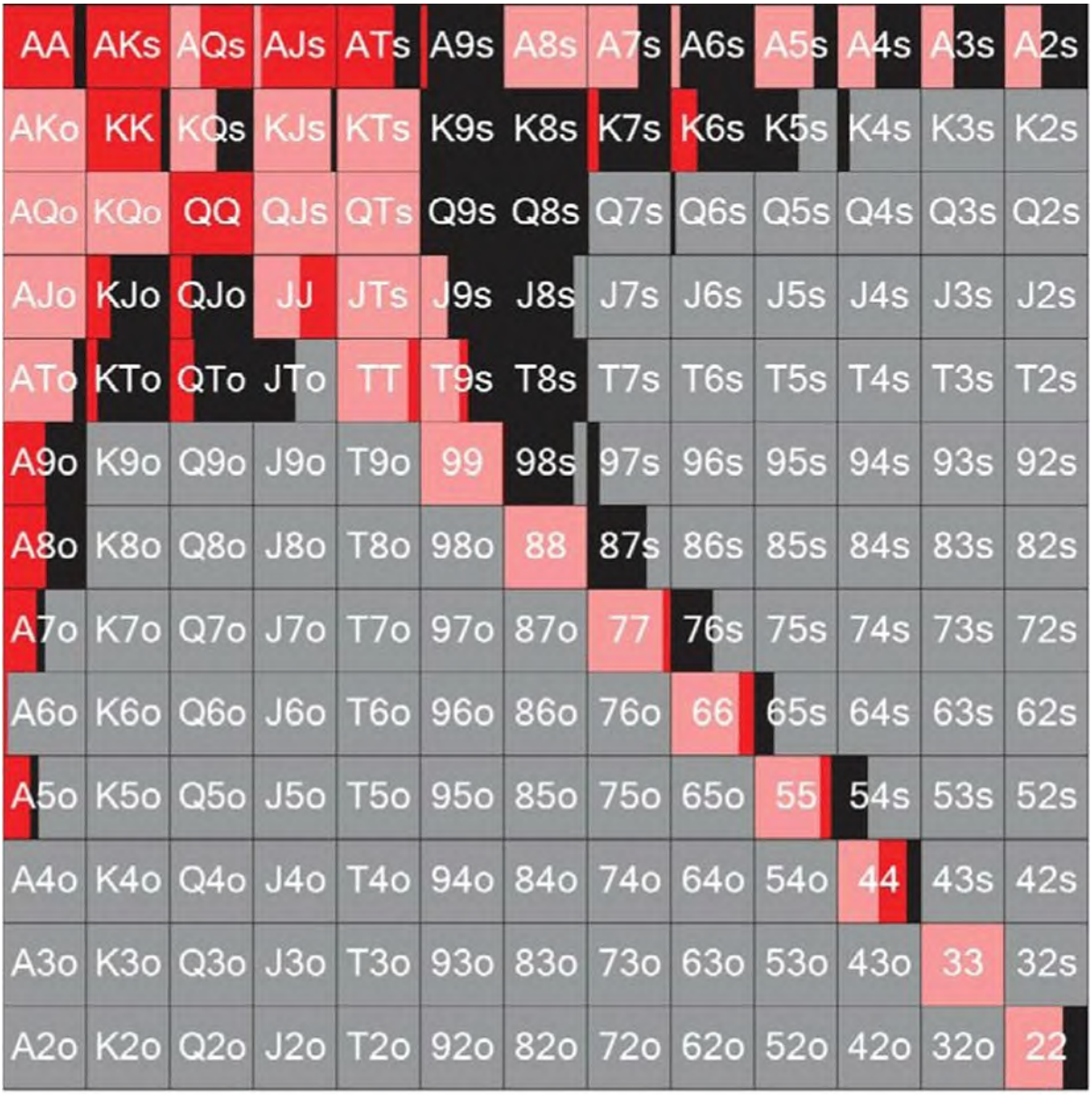
Offsuit hands are mostly folded except for the Ax holdings that are rejammed vs LP. Offsuit broadways can be called vs LP, but have to be folded vs EP. Small pocket pairs make great rejamming hands vs LP but play better as calls vs EP due to the lack of fold equity. Be sure to take note of how SB chooses decently strong hands such as A5s-A2s, AJo and ATo to 3-bet/fold vs EP, whereas the 3-bet fold range against the BN is A8o-A3o, KJo and KTo *(Hand Ranges 187-194)*.



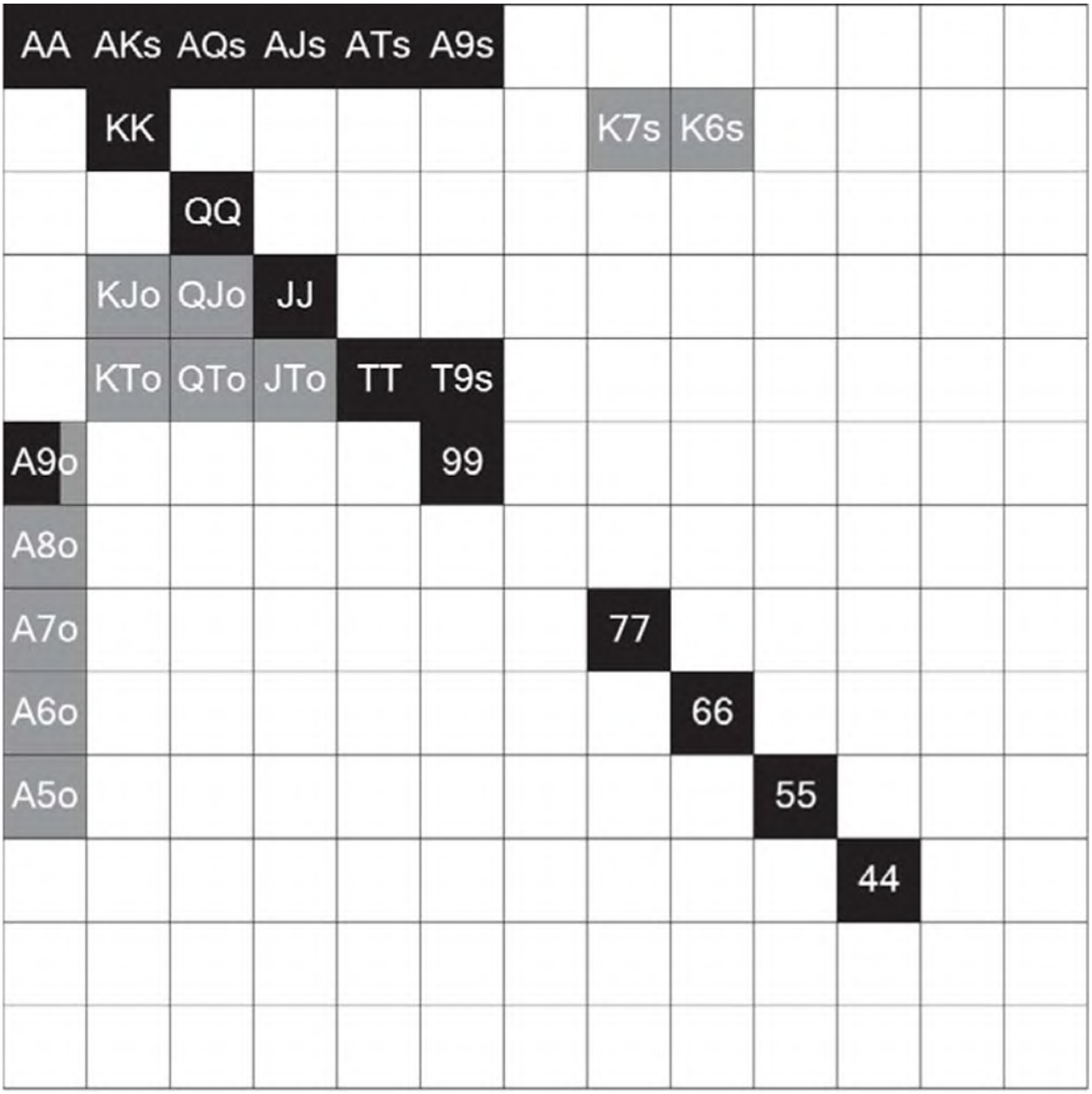
Hand Range 187: SB vs BN (25bb) • All-in 14.2% / • 3-bet 6.5% / • Call 6% / • Fold 73.2%



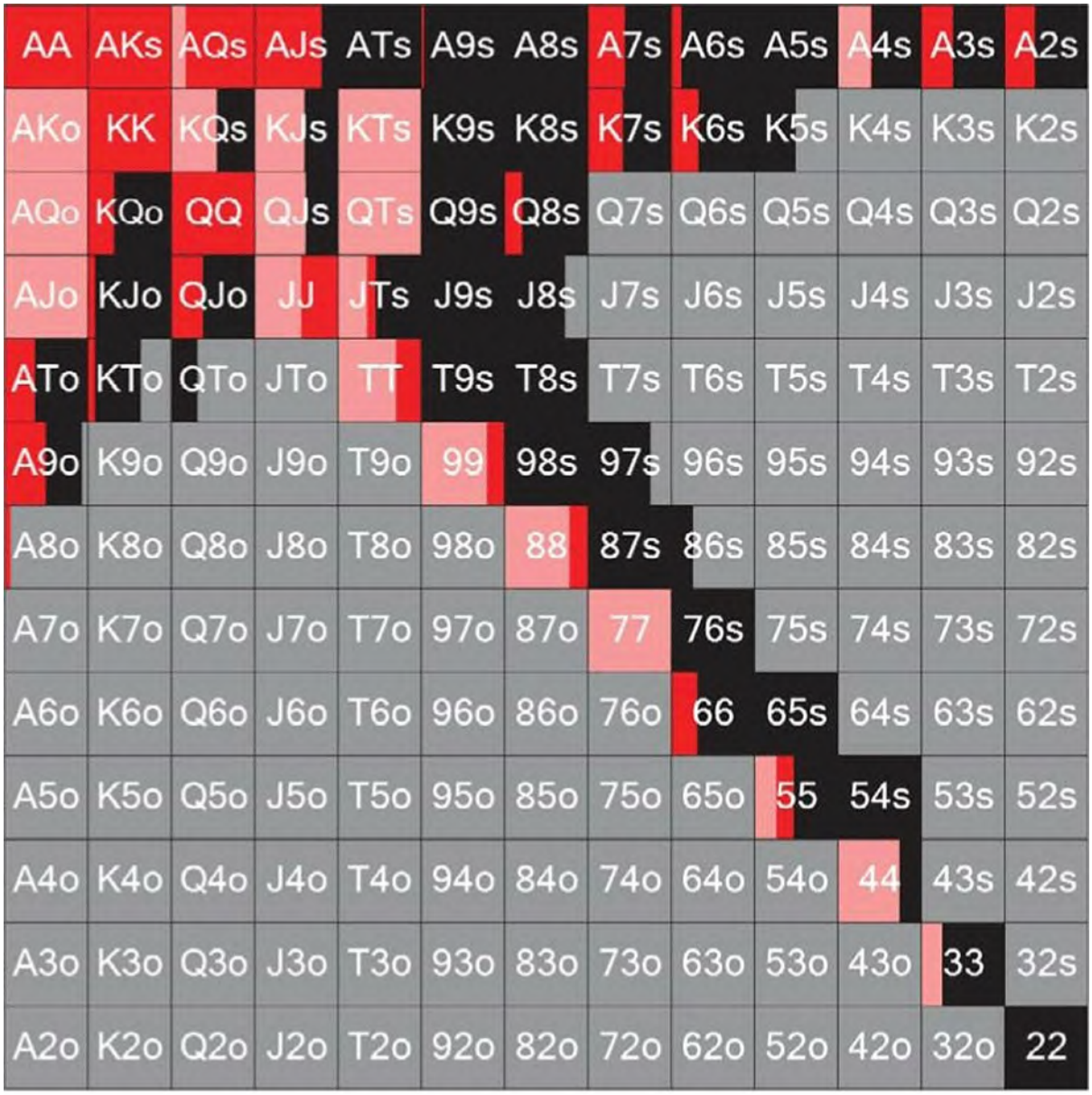
Hand Range 188: SB vs BN 4-bet (25bb) • Call 58.2% / • Fold 41.8%



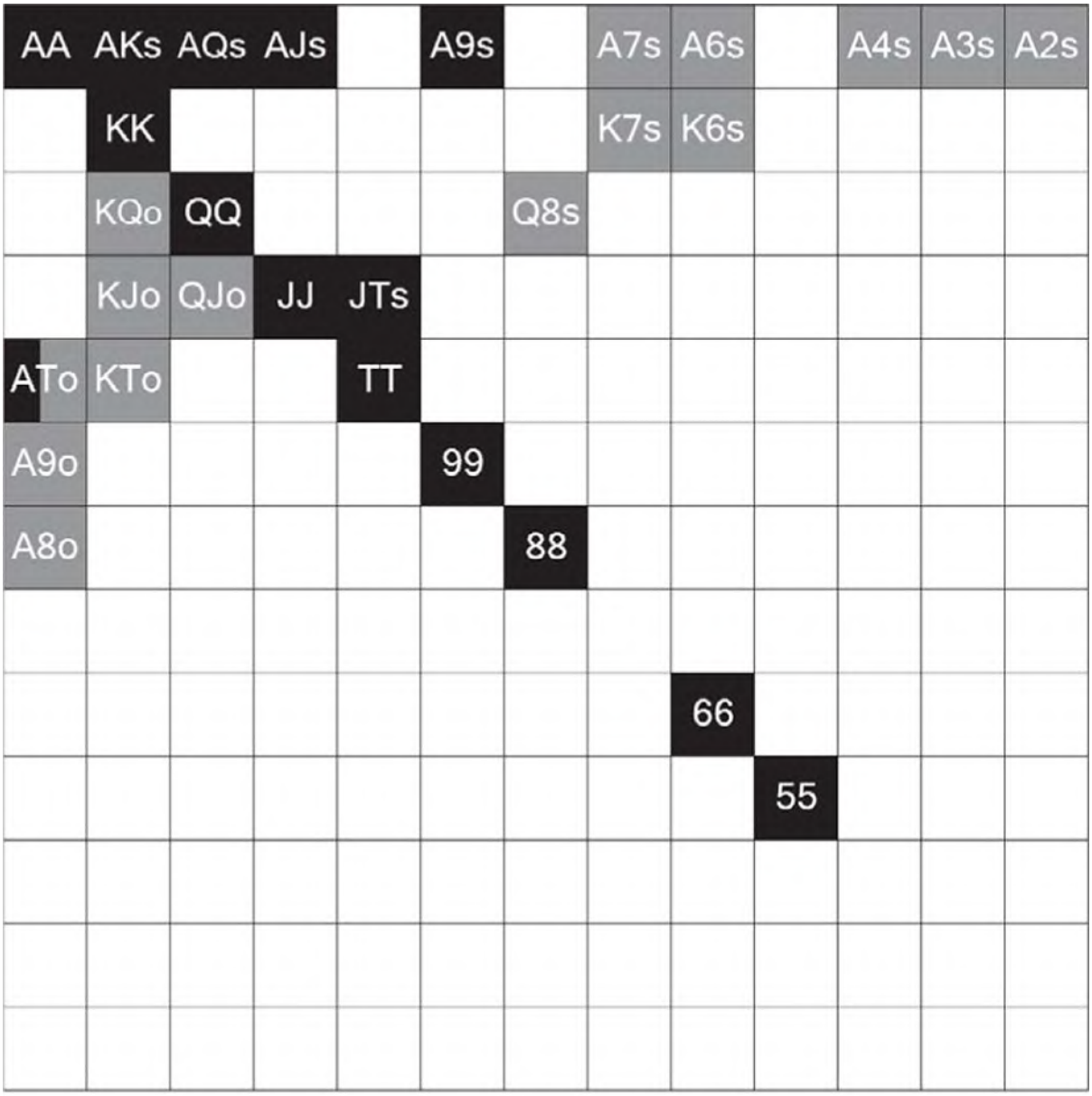
Hand Range 189: SB vs CO (25bb) • All-in 11.2% / • 3-bet 5.5% / • Call 9.9% / • Fold 73.3%



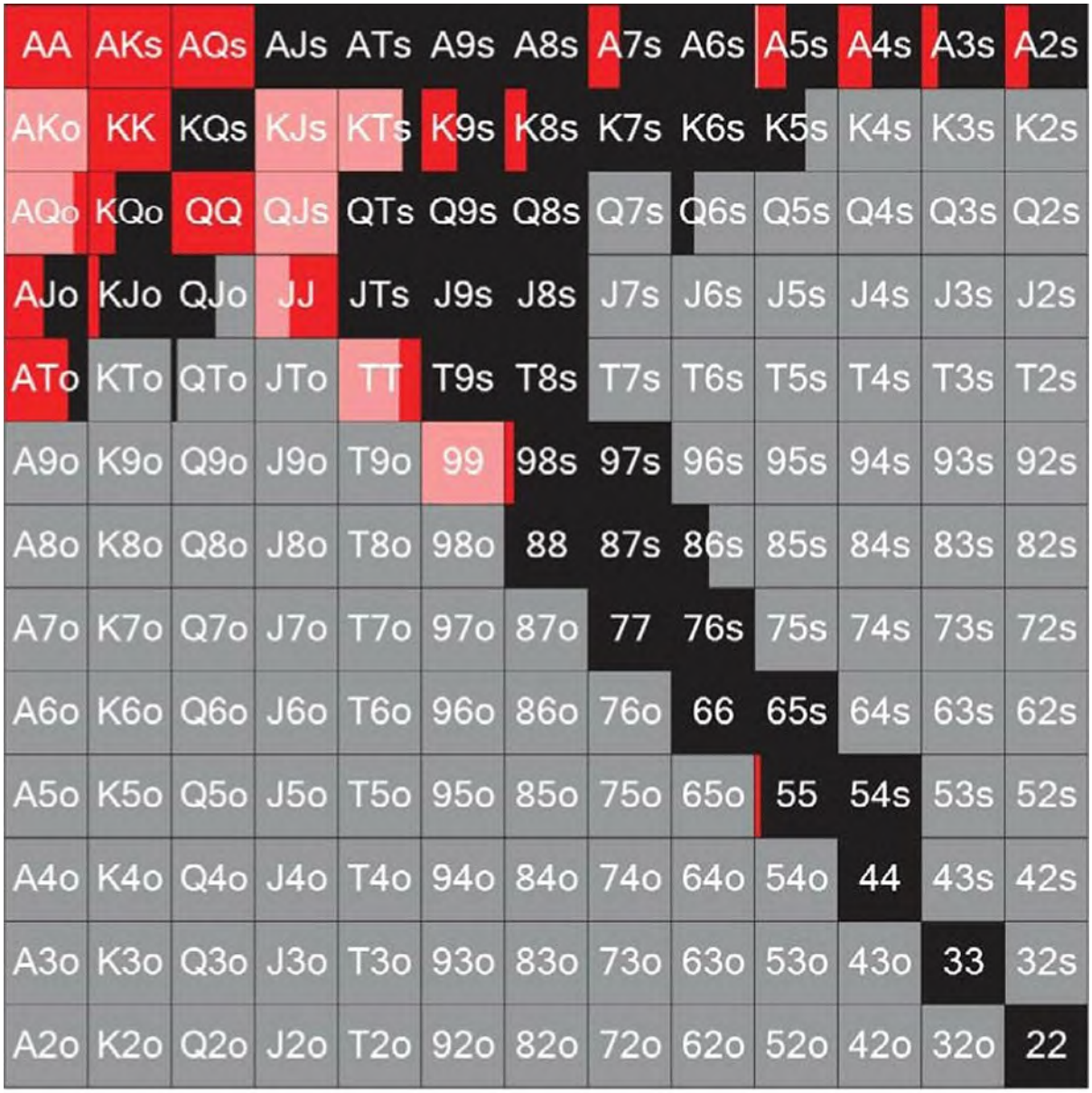
Hand Range 190: SB vs CO 4-bet (25bb) • Call 57.9% / • Fold 42.1%



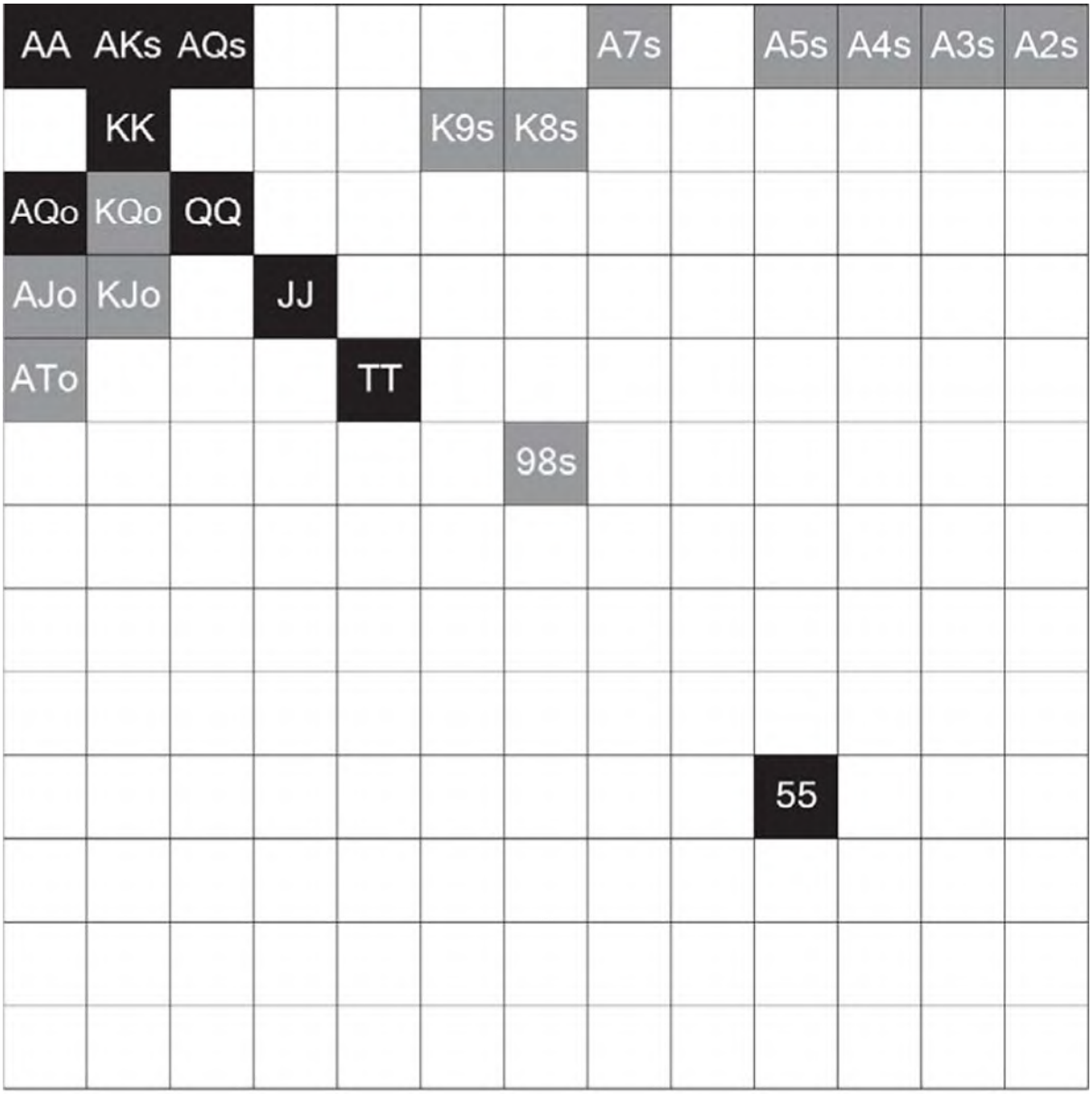
Hand Range 191: SB vs LJ (25bb) • All-in 6.4% / • 3-bet 5.3% / • Call 12.6% / • Fold 75.7%



Hand Range 192: SB vs LJ 4-bet (25bb) • Call 59.1% / • Fold 40.9%



Hand Range 193: SB vs UTG (25bb) • All-in 3.5% / • 3-bet 4.8% / • Call 14.2% / • Fold 77.5%



Hand Range 194: SB vs UTG 4-bet (25bb) • Call 52.8% / • Fold 47.2%

Defending the SB (40bb)

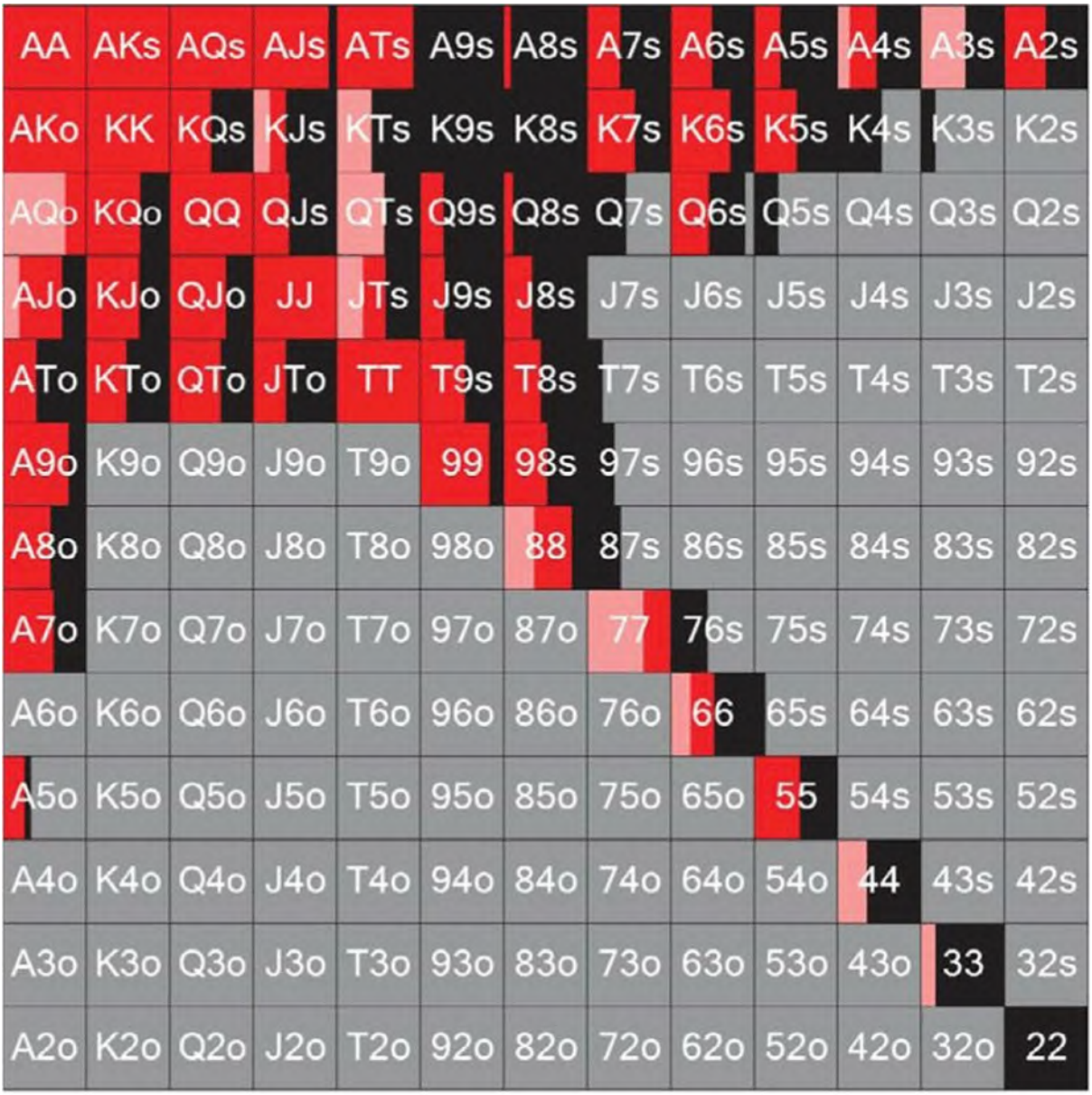
With 40bb, the SB has a tiny 3-bet all-in range vs late and middle position including hands such as 88-66, 44, 33, AQo, AJo, A4s, A3s, KJs, KTs, QTs and JTs, but the range is so small that, in practice, I prefer to not have a 3-bet all-in range at all.

BB vs	All-in	3-bet	Call	Fold
BN	2.30%	14.10%	11.70%	71.80%
CO	1.00%	12.10%	12.70%	74.20%
HJ	1.10%	9.70%	10.90%	78.30%
LJ	1.00%	8.00%	12.20%	78.80%
UTG+2	0.20%	8.00%	12.40%	79.40%
UTG+1	0.00%	6.90%	12.90%	80.30%
UTG	0.00%	6.60%	12.70%	80.70%
Average	0.80%	9.34%	12.21%	77.64%

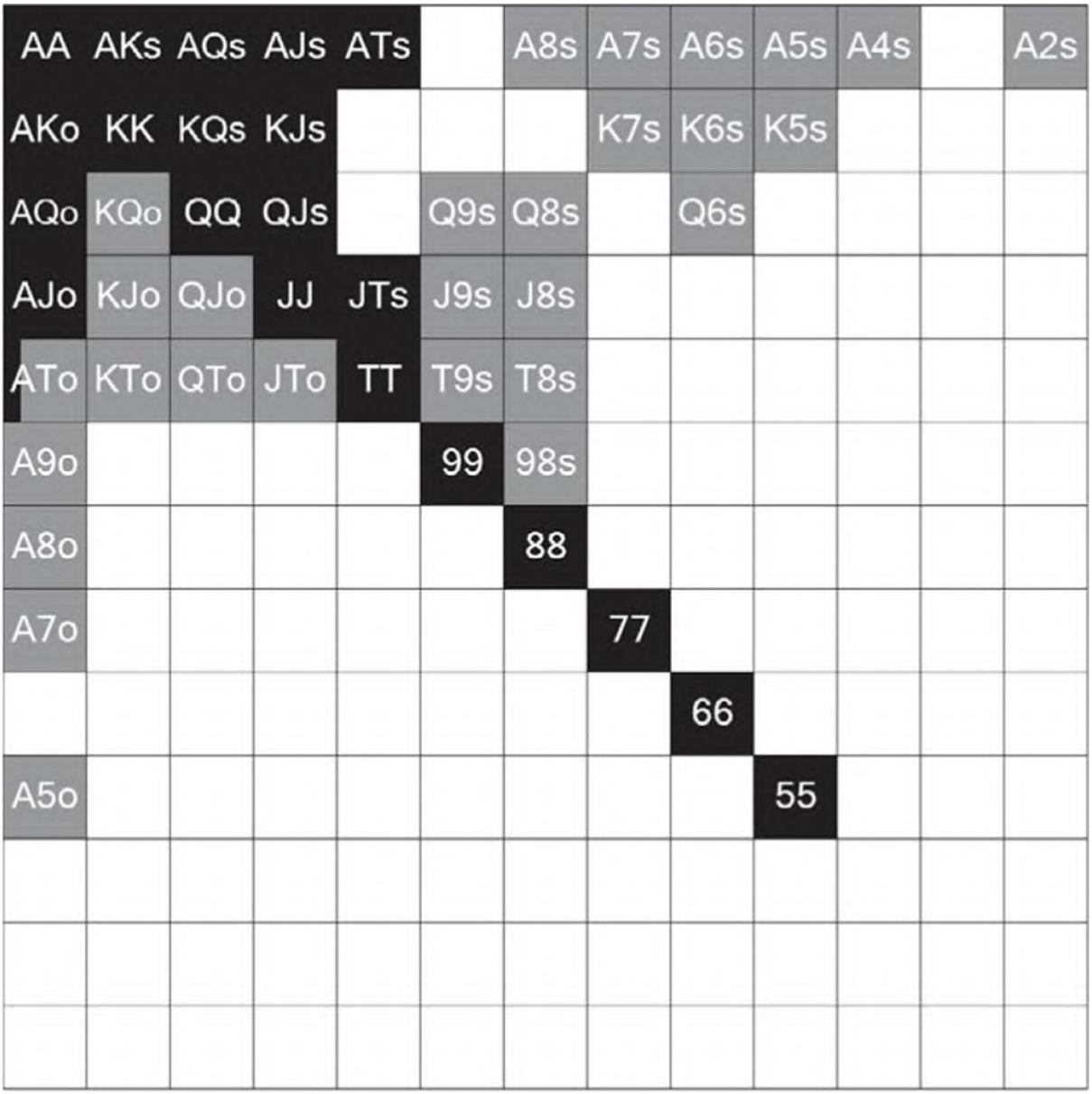
Table 65: SB Action Frequencies (40bb)

At this stack depth, the SB calling range remains constant vs all positions, around the 12.21% average. The main difference being that medium Axo and offsuit broadways get folded vs EP while they sometimes get called vs LP.

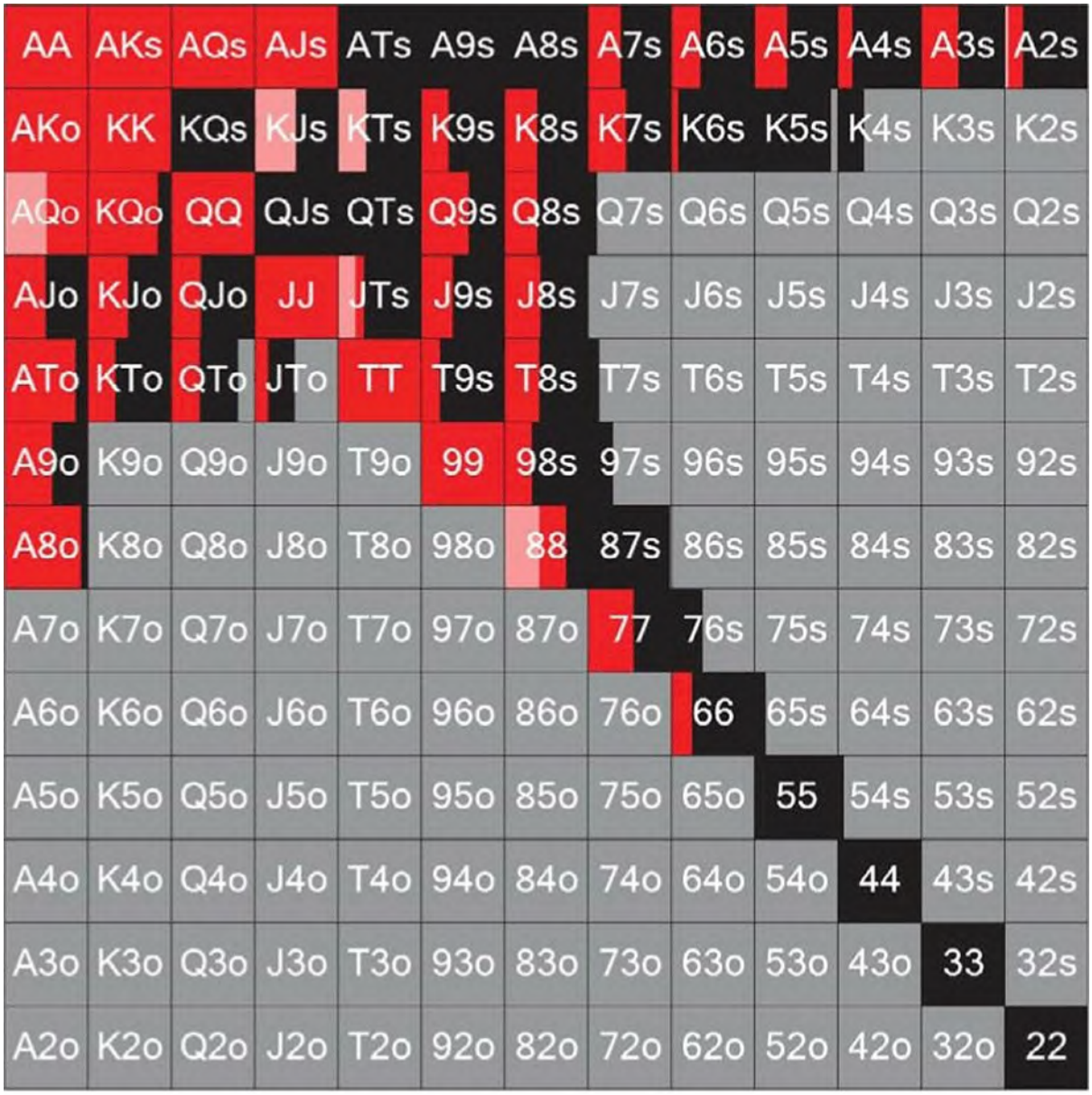
The non-all-in 3-betting range increases drastically from 6.6% vs UTG to 14.1% vs the BN, with the SB expanding its value range vs the BN to include hands such as AQs-ATs, AJo and 55+ and the 3-bet/fold range to include A9o-A7o, K7s-K5s and offsuit broadways *(Hand Ranges 195-202)*.



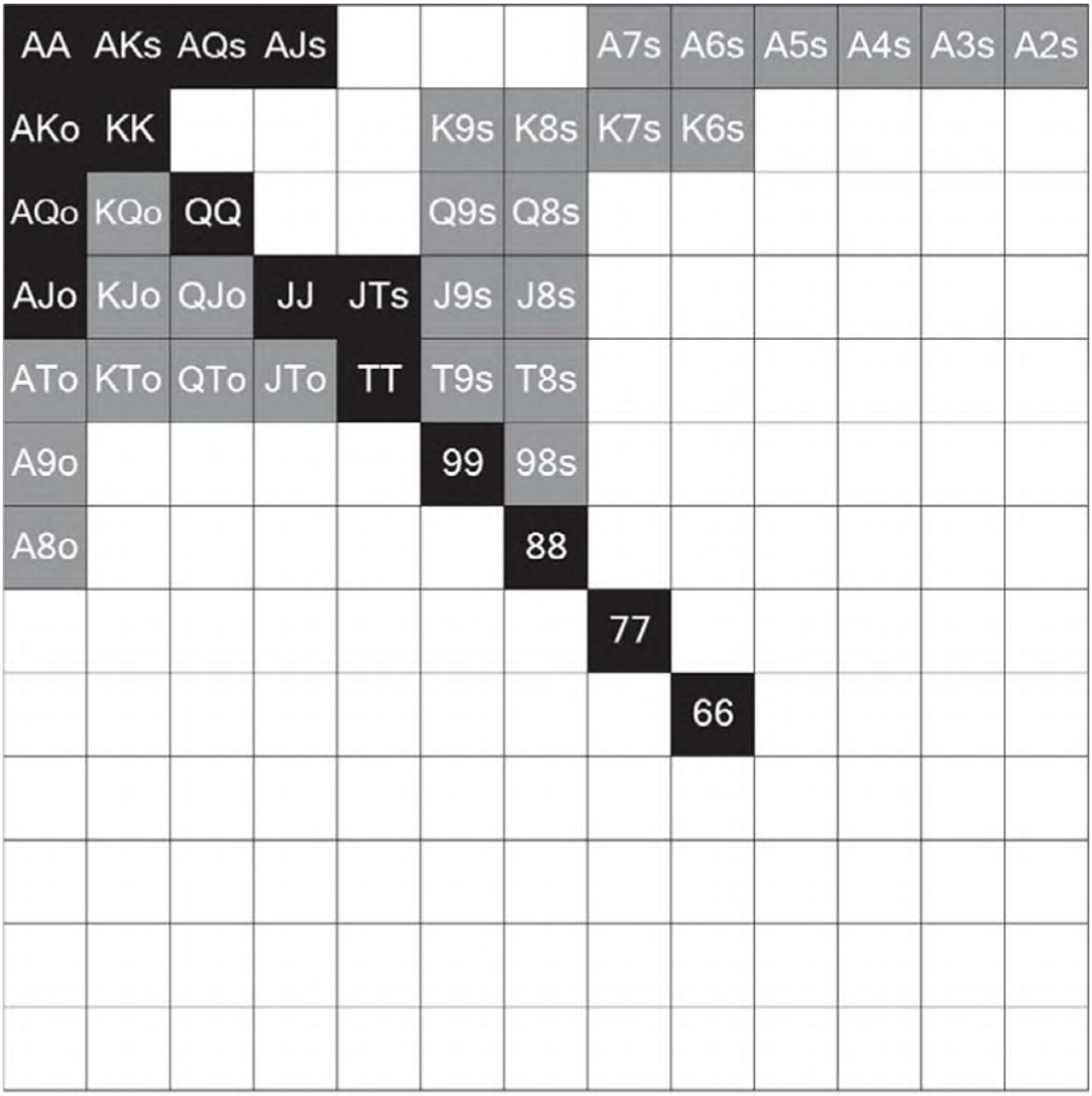
Hand Range 195: SB vs BN (40bb) • All-in 2.3% / • 3-bet 14.1% / • Call 11.7% / • Fold 71.8%



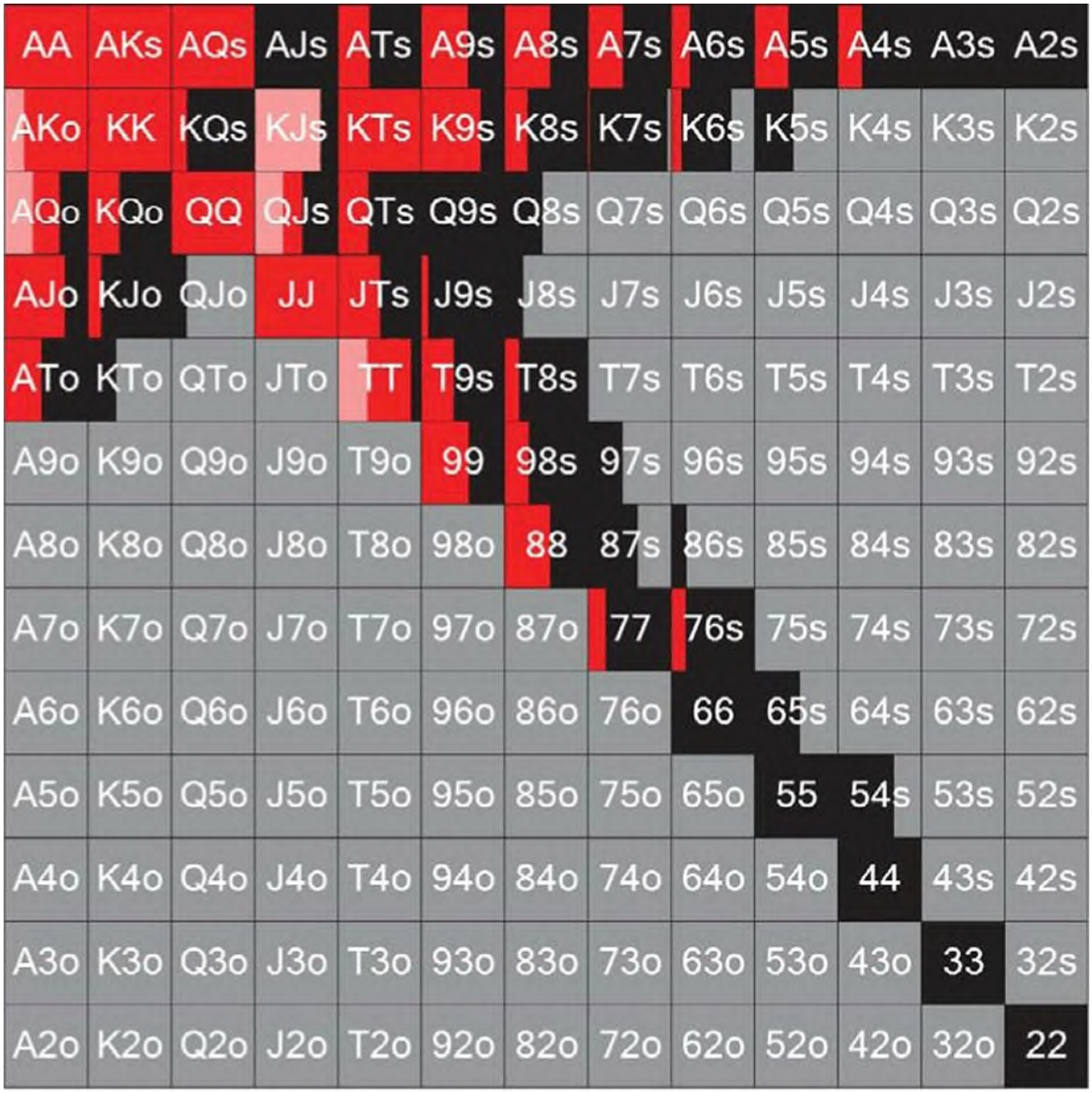
Hand Range 196: SB vs BN 4-bet (40bb) • Call 52.8% / • Fold 47.2%



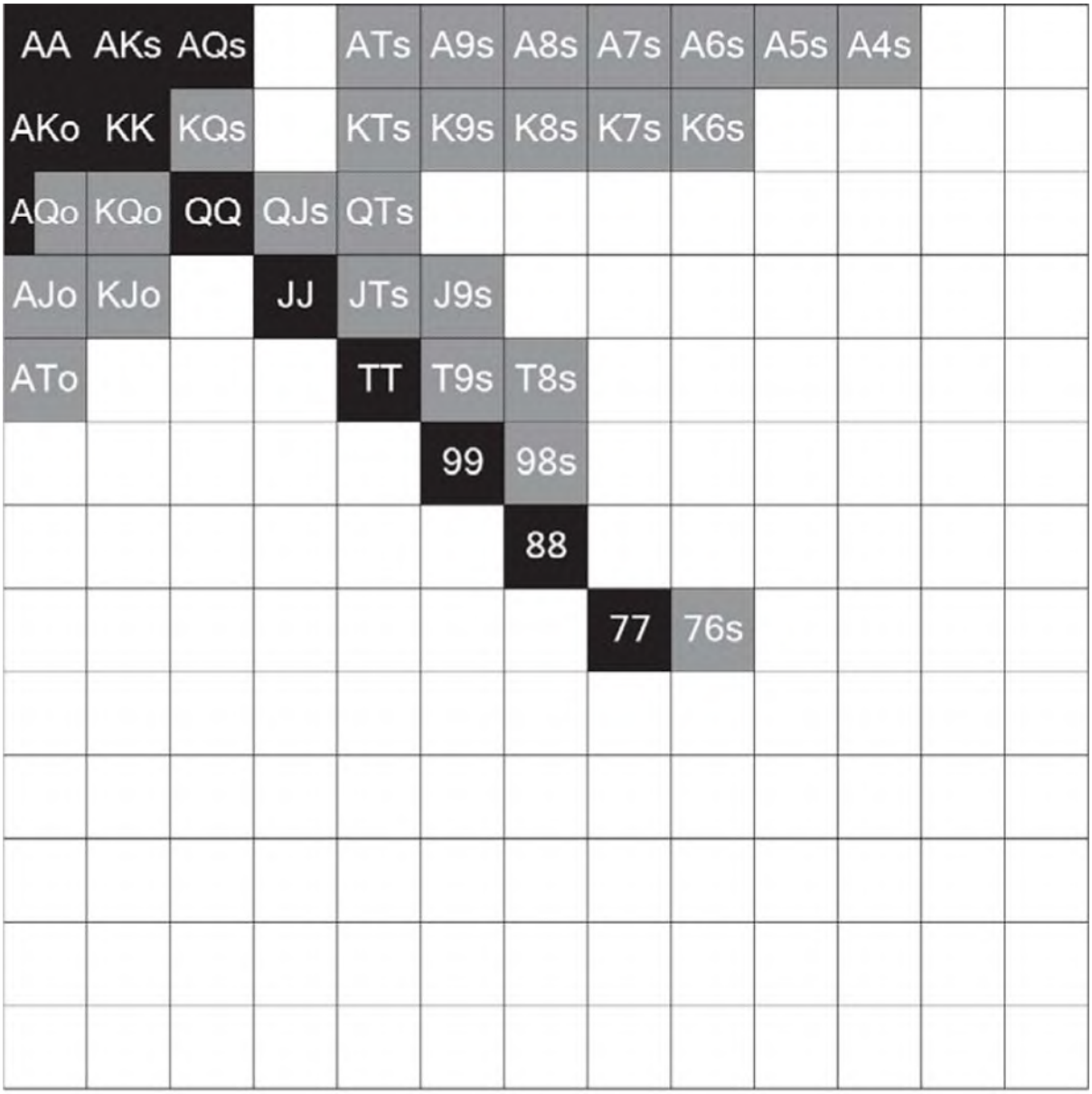
Hand Range 197: SB vs CO (40bb) • All-in 1% / • 3-bet 12.1% / • Call 12.7% / • Fold 74.2%



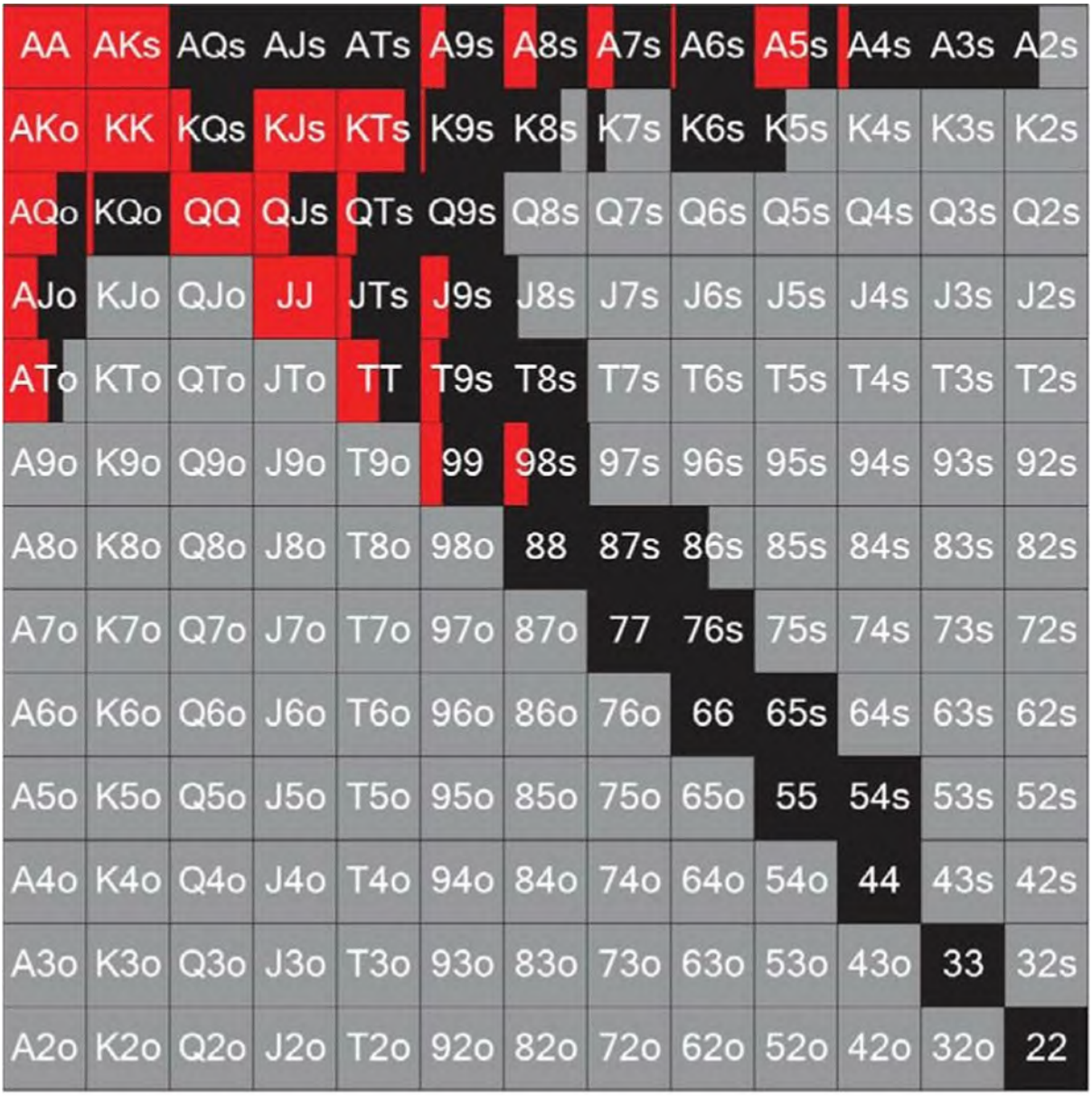
Hand Range 198: SB vs CO 4-bet (40bb) • Call 49.1% / • Fold 50.9%



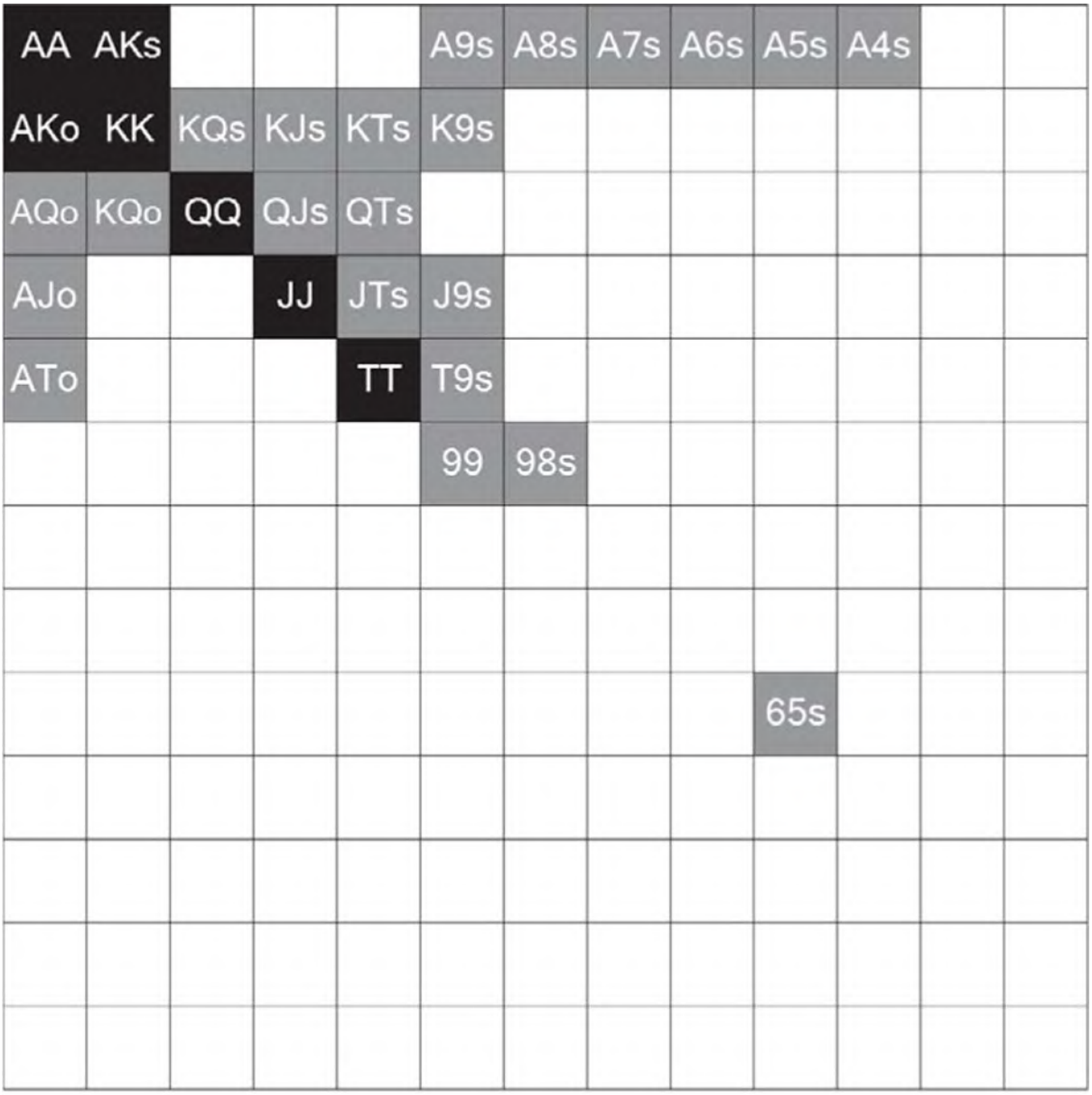
Hand Range 199: SB vs LJ (40bb) • All-in 1% / • 3-bet 8% / • Call 12.2% / • Fold 78.8%



Hand Range 200: SB vs LJ 4-bet (40bb) • Call 50.8% / • Fold 49.2%



Hand Range 201: SB vs UTG (40bb) • 3-bet 6.6% / • Call 12.7% / • Fold 80.7%



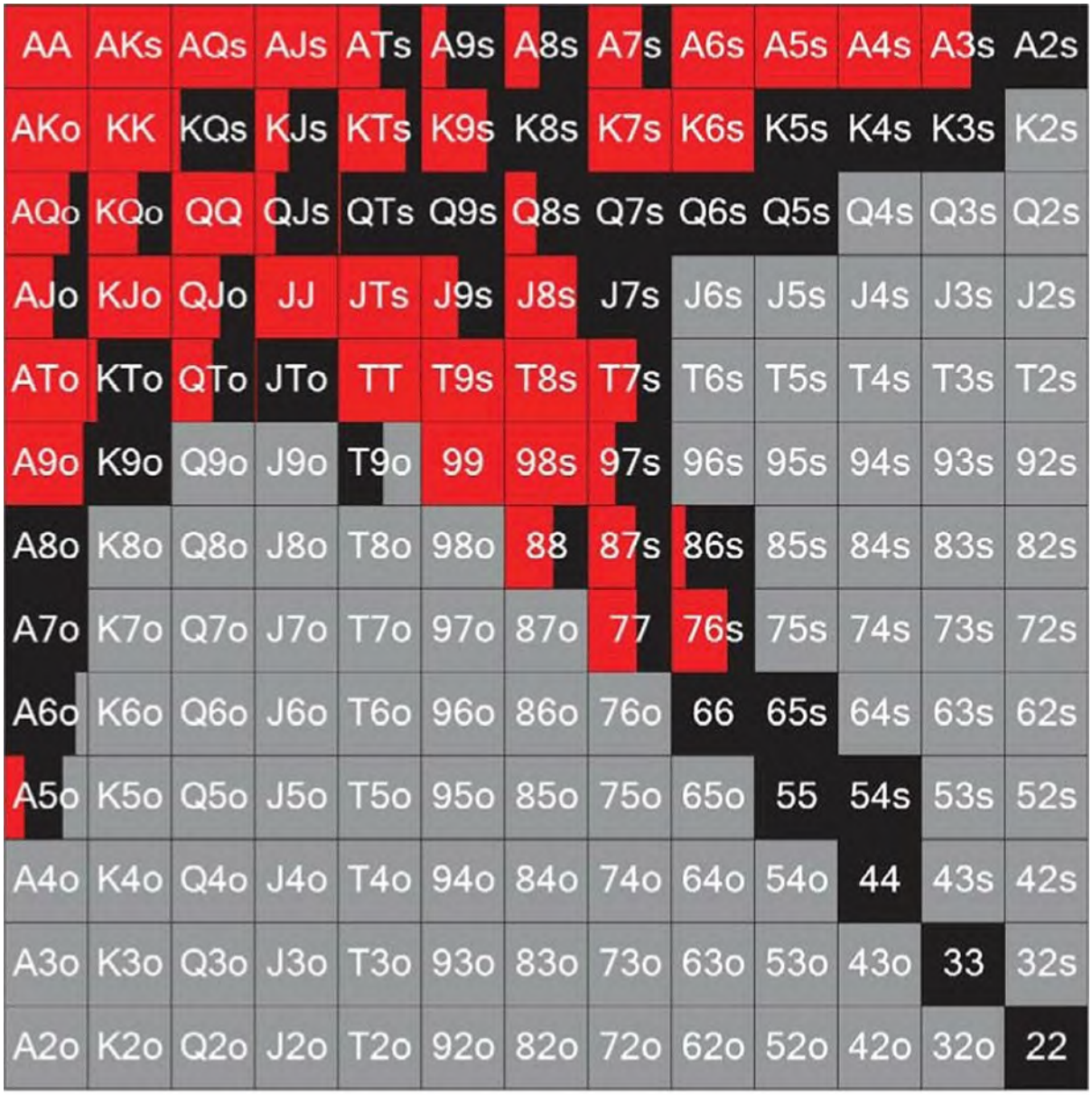
Hand Range 202: SB vs UTG 4-bet (40bb) • Call 49.2% / • Fold 50.8%

Defending the SB (60bb)

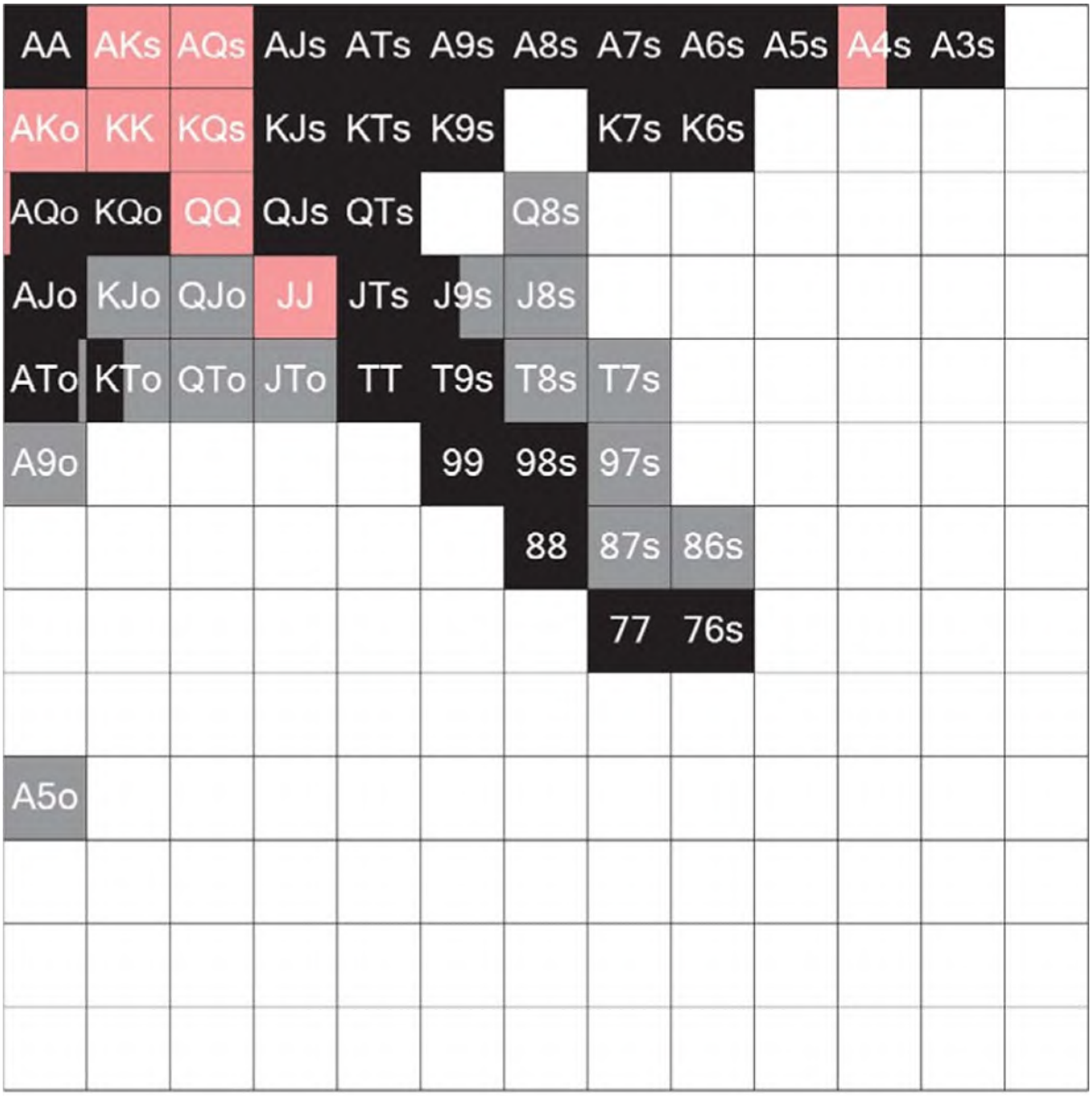
SB vs	All-in	Call	Fold
BN	16.20%	17.20%	66.60%
CO	12.30%	15.60%	72.20%
HJ	9.60%	15.70%	74.70%
LJ	8.10%	13.90%	78.10%
UTG+2	7.60%	12.90%	79.50%
UTG+1	7.00%	12.70%	80.30%
UTG	5.60%	13.80%	80.60%
Average	9.49%	14.54%	76.00%

Table 66: SB Action Frequencies (60bb)

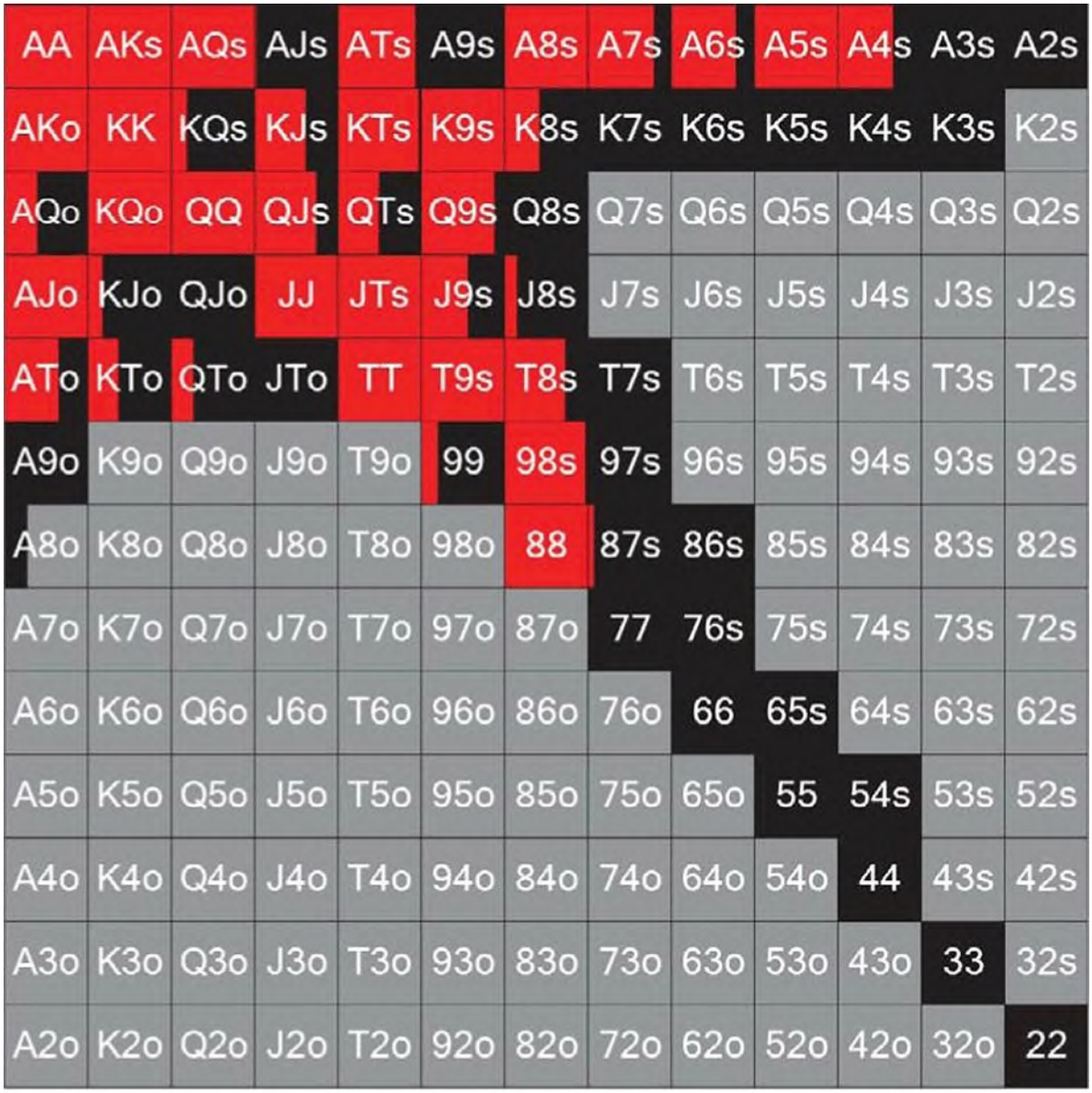
The average SB VPIP is 24%, going from 33.4% VPIP vs the BN to 19.4% vs UTG. As the stacks get deeper, there is a preference towards 3-betting hands with better post-flop playability, given the high likelihood that the play will get to the flop, forcing the SB to play post-flop OOP. Also, since IP is too deep to 4-bet jam, the SB will be able to call many hands vs a 4-bet and play post-flop with high equity hands that play well in 4-bet pots *(Hand Ranges 203-210)*.



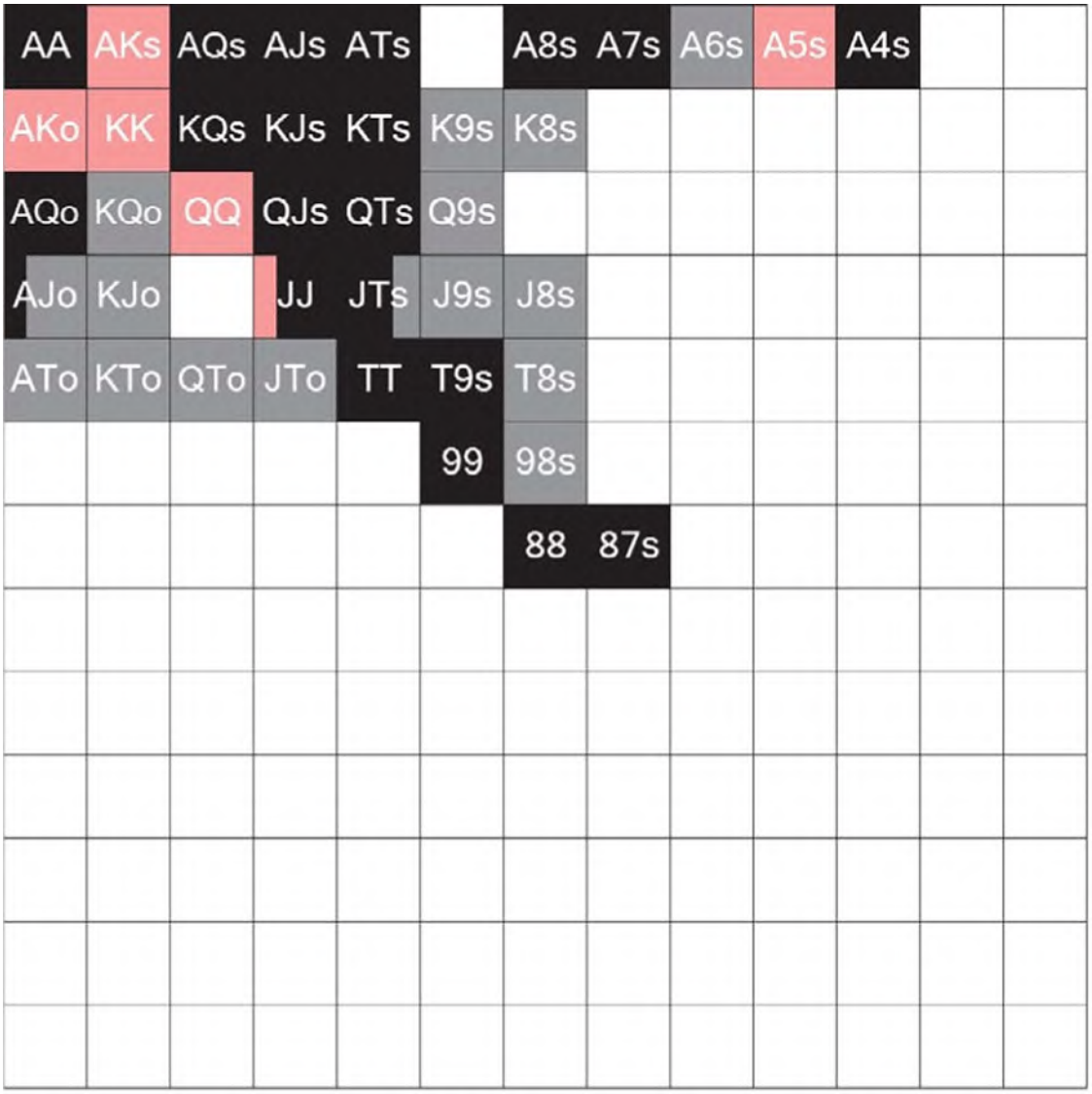
Hand Range 203: SB vs BN (60bb) • 3-bet 16.2% / • Call 17.2% / • Fold 66.6%



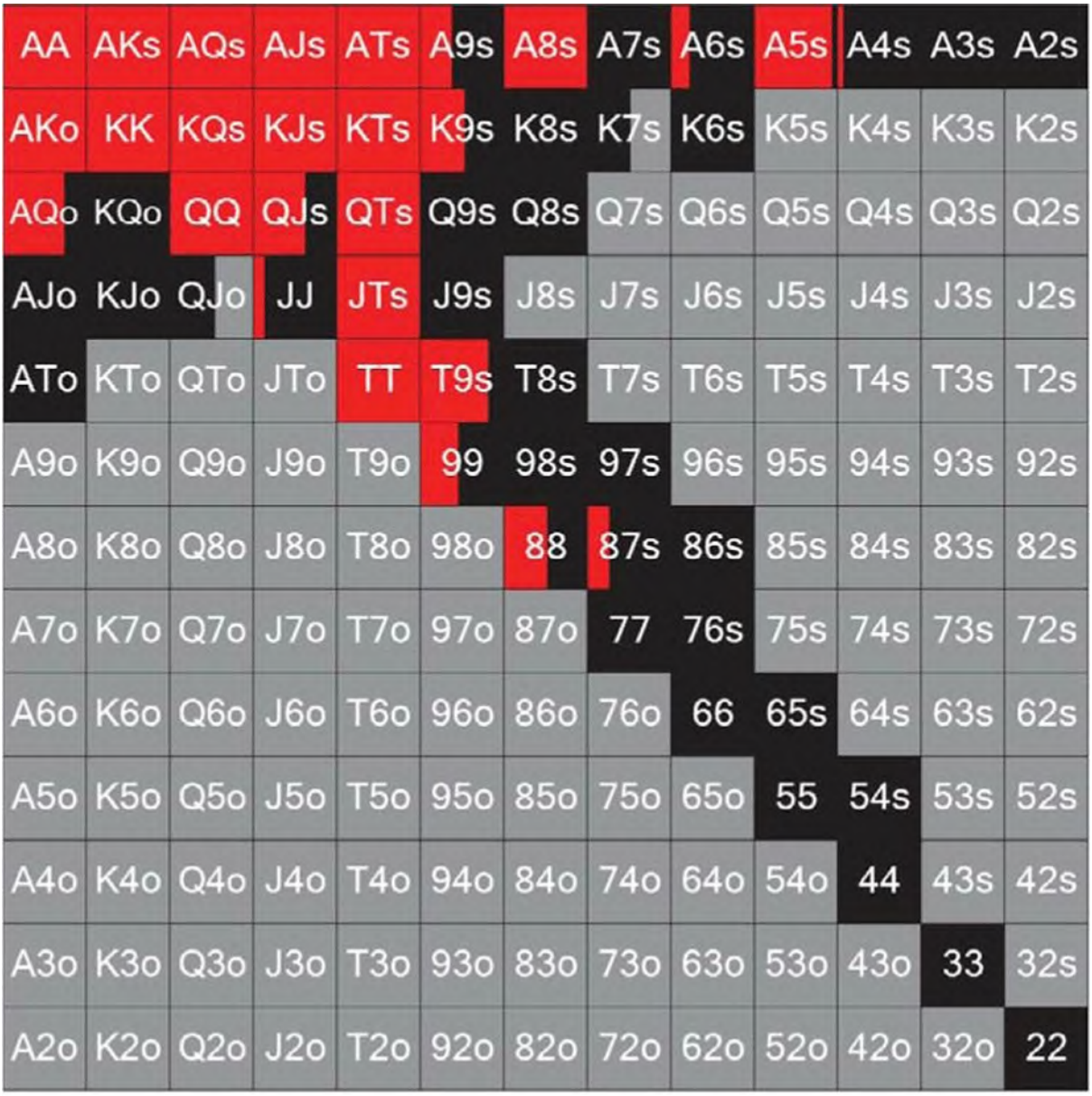
Hand Range 204: SB vs BN 4-bet (60bb) • All-in 19.3% / • Call 53.8% / • Fold 26.9%



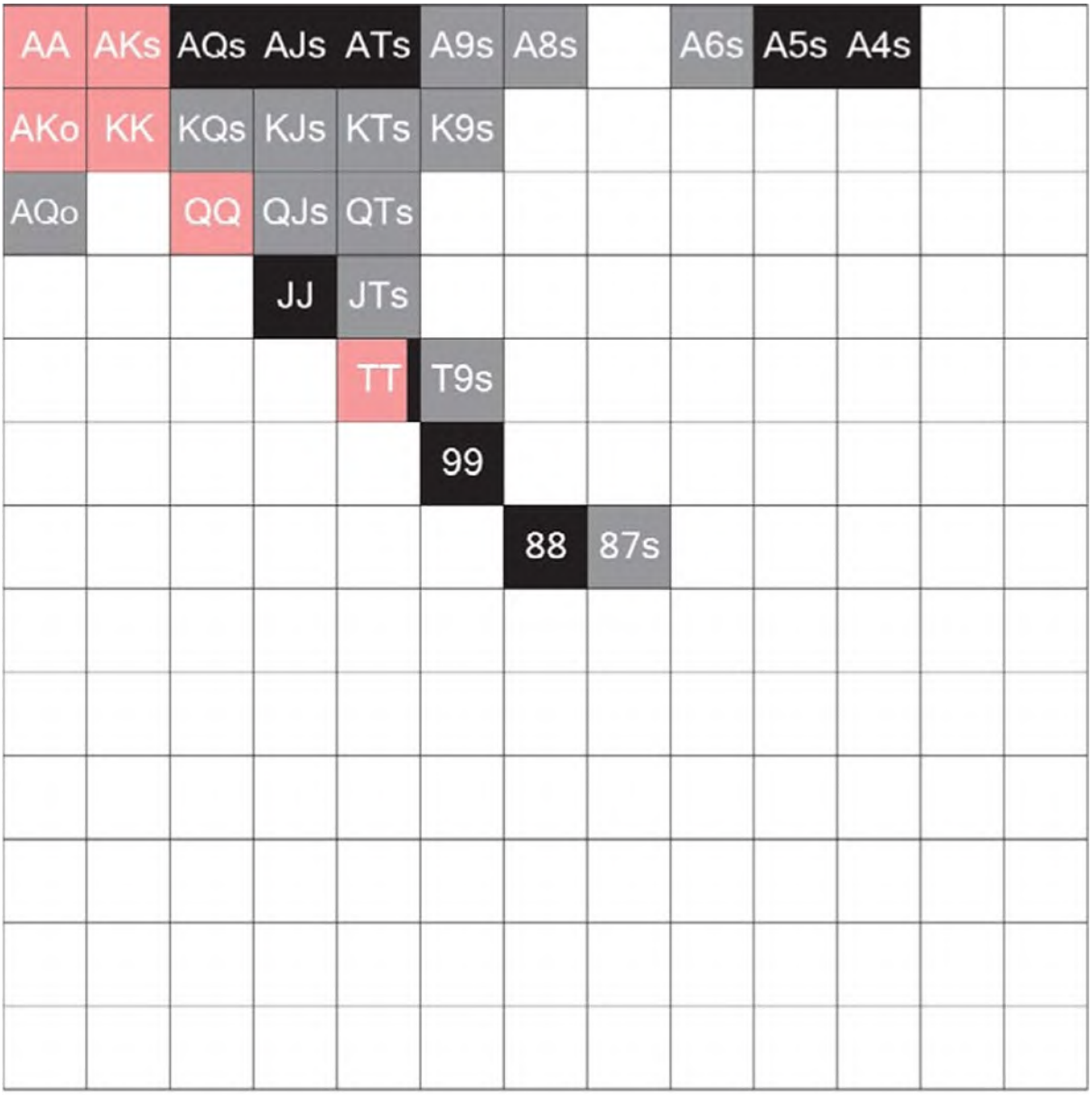
Hand Range 205: SB vs CO (60bb) • 3-bet 12.3% / • Call 15.6% / • Fold 72.2%



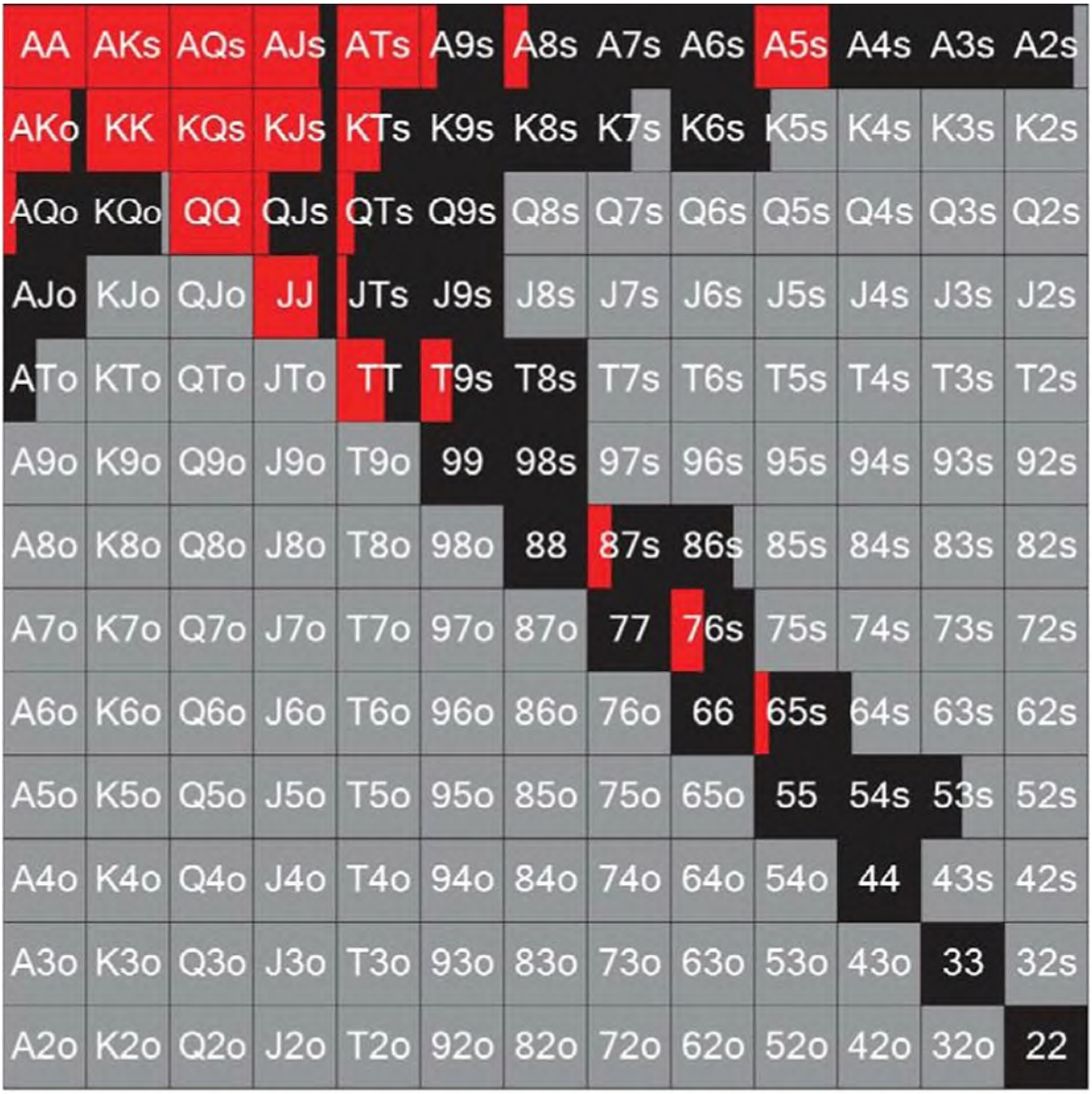
Hand Range 206: SB vs CO 4-bet (60bb) • All-in 20.6% / • Call 41.8% / • Fold 37.6%



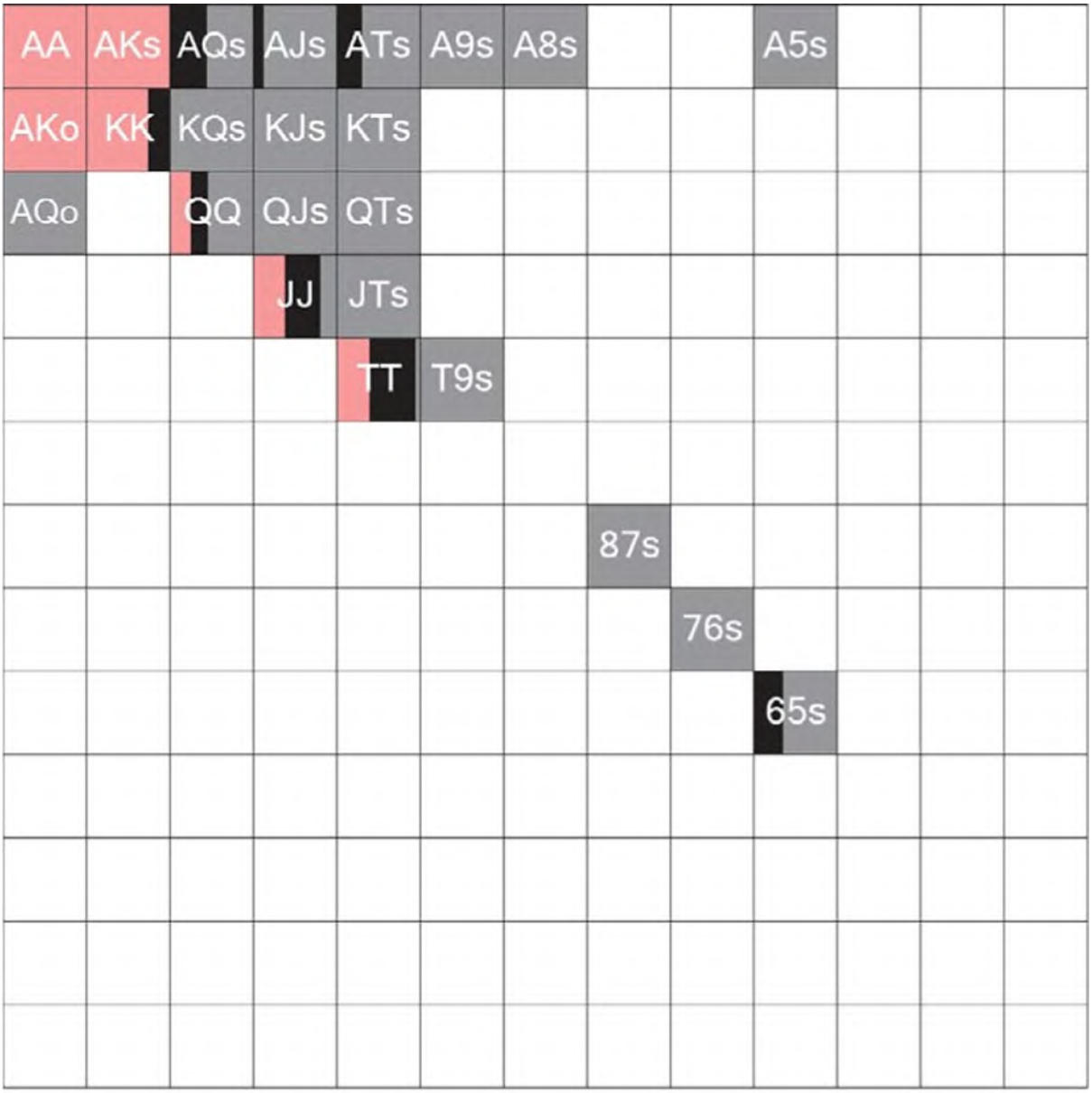
Hand Range 207: SB vs LJ (60bb) • 3-bet 8.1% / • Call 13.9% / • Fold 78.1%



Hand Range 208: SB vs LJ 4-bet (60bb) • All-in 36.5% / • Call 22.1% / • Fold 41.4%



Hand Range 209: SB vs UTG (60bb) • 3-bet 5.6% / • Call 13.8% / • Fold 80.6%



Hand Range 210: SB vs UTG 4-bet (60bb) • All-in 38.5% / • Call 13.9% / • Fold 47.6%

Defending the Button

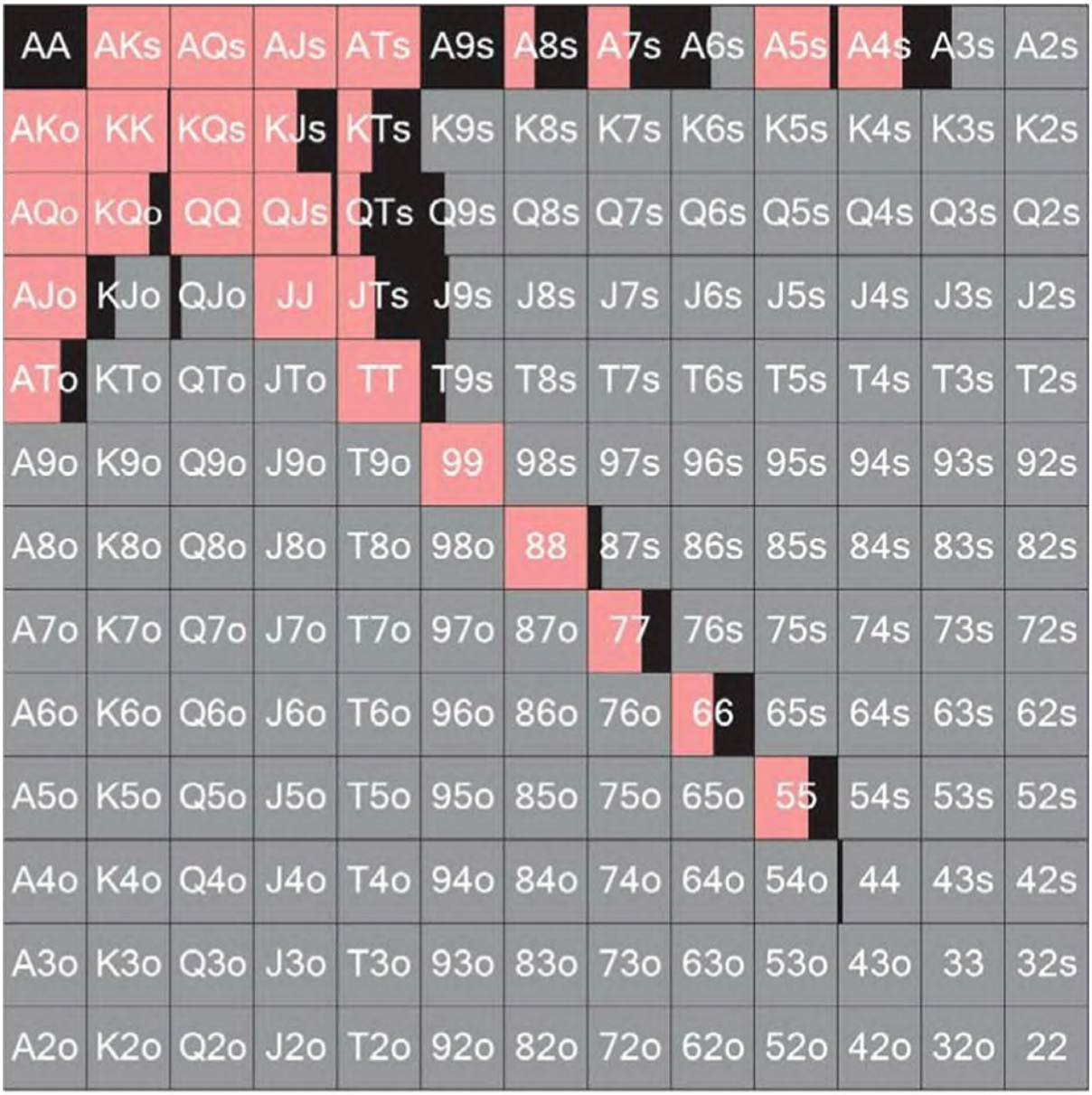
Defending the BN (15bb)

BN vs	All-in	Call	Fold
CO	14.30%	4.10%	81.60%
HJ	12.30%	3.80%	83.90%
LJ	10.60%	4.00%	85.40%
UTG+2	9.90%	3.70%	86.40%
UTG+1	7.80%	5.00%	87.20%
UTG	7.50%	5.00%	87.50%
Average	10.40%	4.27%	85.33%

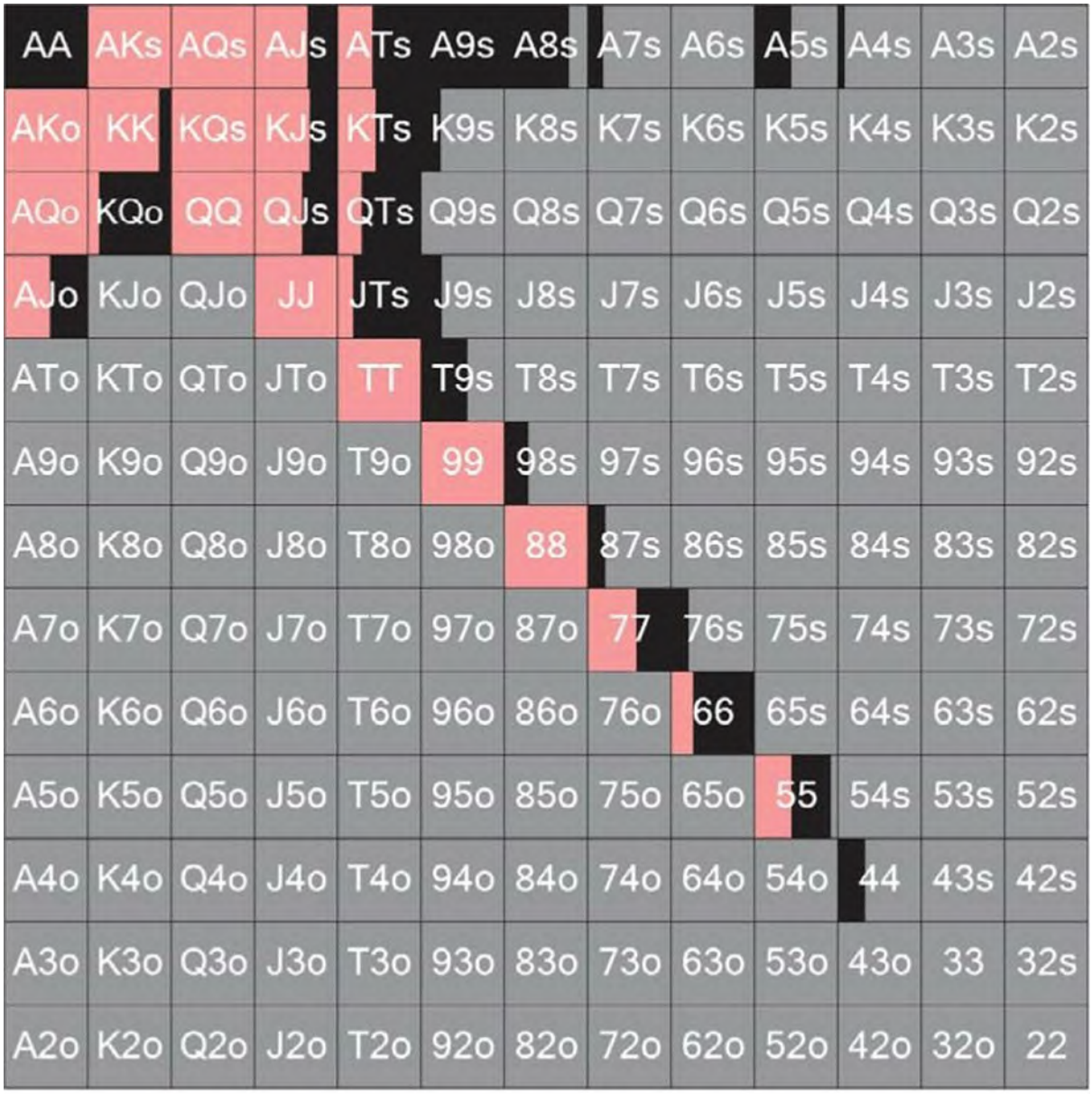
Table 67: BN Action Frequencies (15bb)

With 15bb, the BN VPIP is, on average, 15% of hands. The calling range remains constant at 5% with the hands consisting mostly of middle to small pocket pairs, suited broadways, suited Ax and slow played AA *(Hand Ranges 211-213)*.

Hand Range 211: BN vs CO (15bb) • All-in 14.3% / • Call 4.1% / • Fold 81.6%



Hand Range 212: BN vs LJ (15bb) • All-in 10.6% / • Call 4% / • Fold 85.4%



Hand Range 213: BN vs UTG (15bb) • All-in 10.6% / • Call 4% / • Fold 85.4%

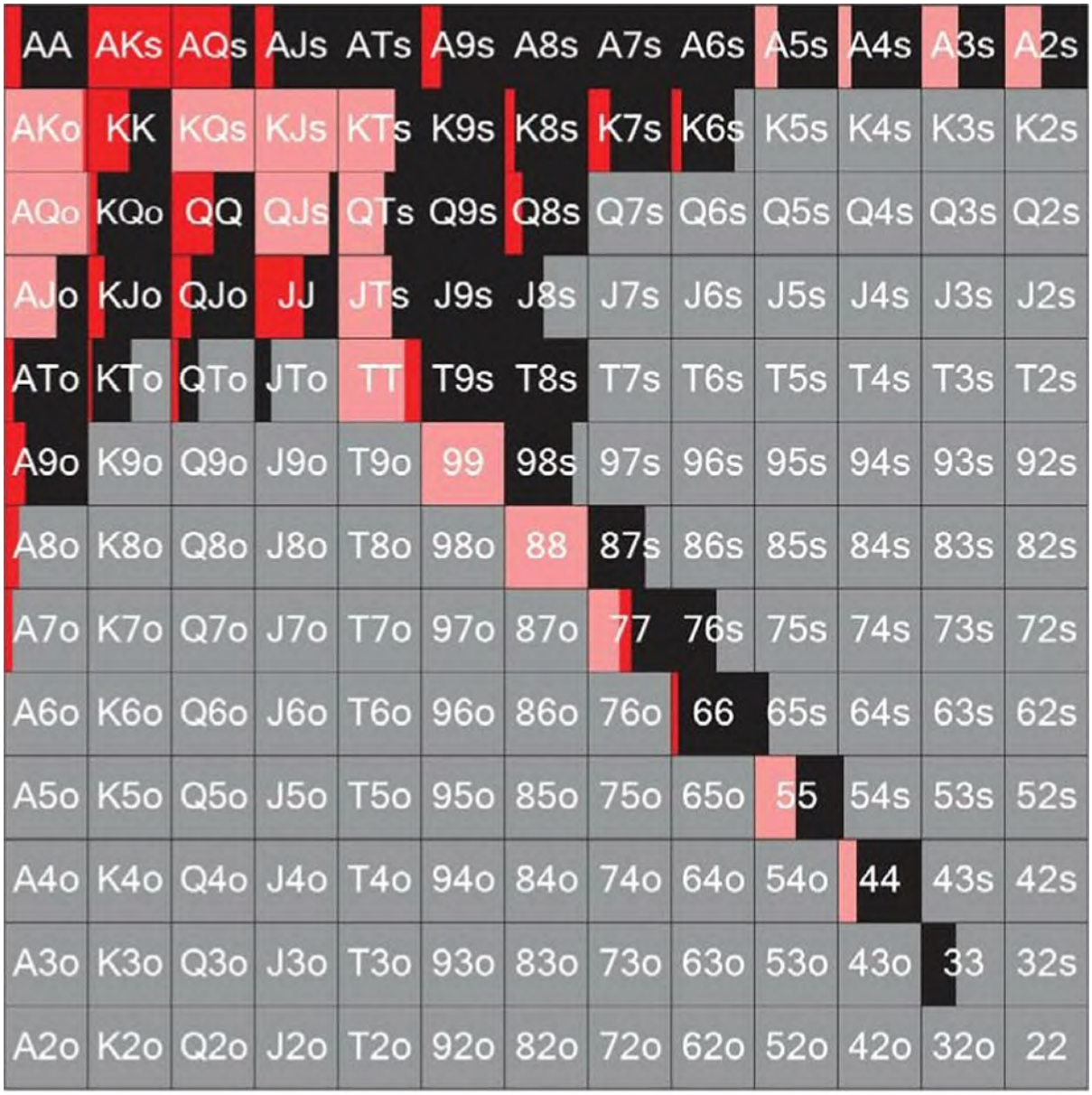
Defending the BN (25bb)

BN vs	All-in	3-bet	Call	Fold
CO	5.90%	3.00%	13.50%	77.50%
HJ	4.40%	2.90%	14.40%	78.30%
LJ	3.50%	3.50%	13.80%	79.30%
UTG+2	2.60%	3.60%	14.50%	79.30%
UTG+1	2.00%	3.20%	14.50%	80.20%
UTG	1.20%	3.70%	14.60%	80.50%
Average	3.27%	3.32%	14.22%	79.18%

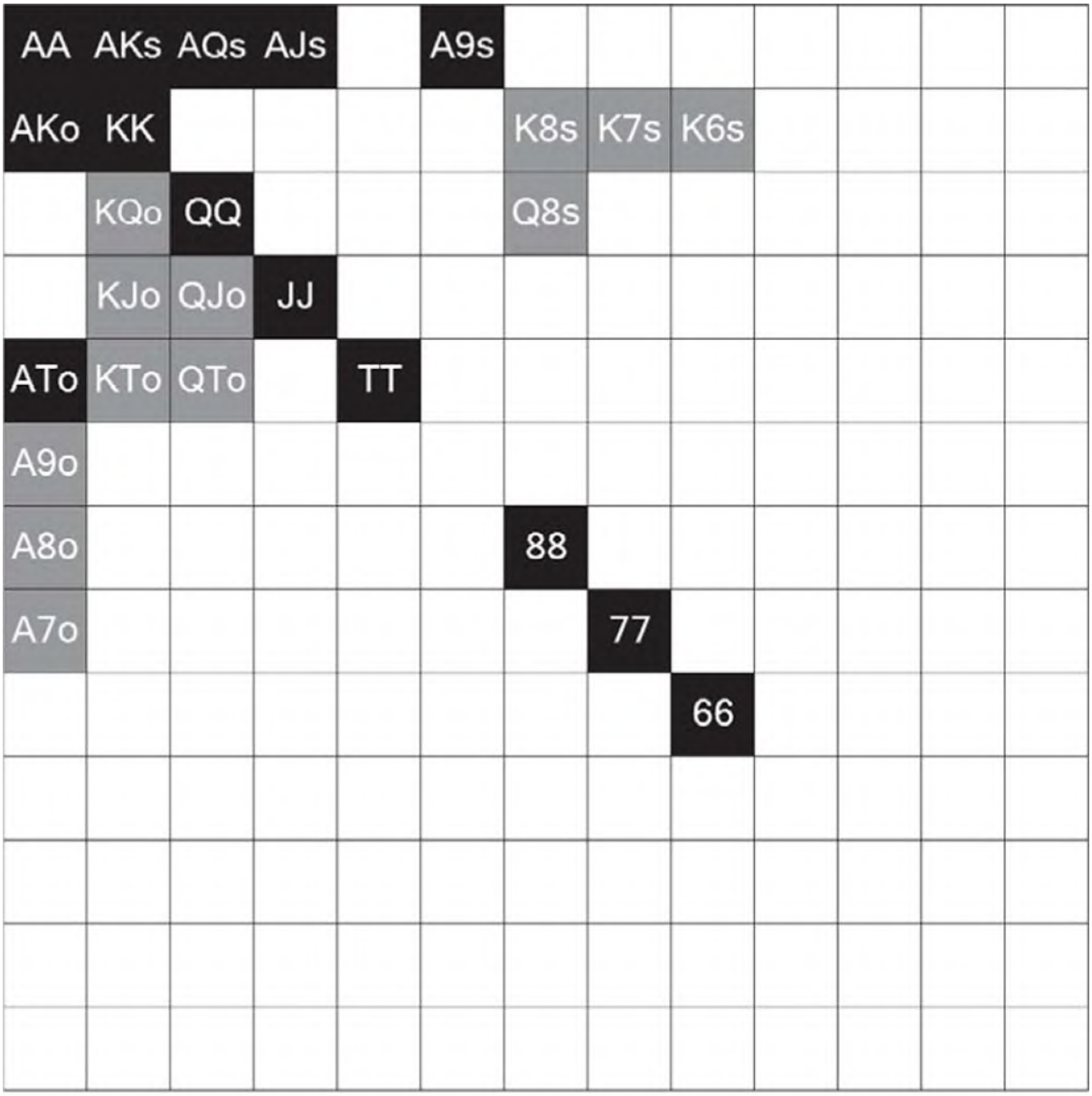
Table 68: BN Action Frequencies (25bb)

With 25bb, the BN gets to VPIP 21% of hands, rejamming aggressively vs the CO at 5.9%, but almost never vs UTG at 1.2%. In practice, the rejamming ranges are so small vs EP that I prefer to scrap them and play a simpler, easier to implement strategy.

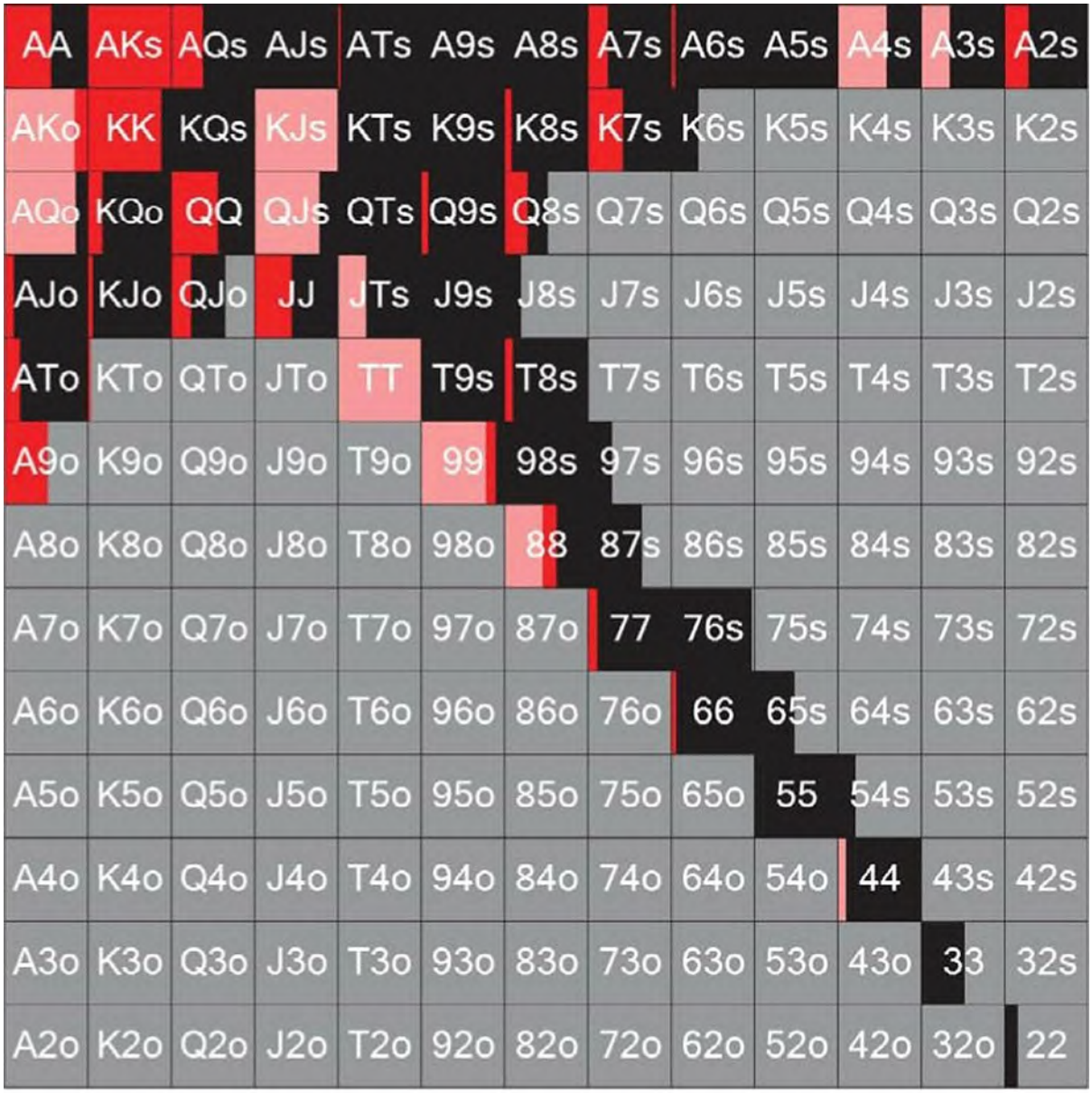
The non-all-in 3-betting range remains constant at roughly 3.32%, as well as the calling range at roughly 14.22%. The flatting hands have great equity and will benefit from having position post-flop, including small and medium pocket pairs, suited Ax, suited connectors and broadways plus some traps with AA and KK *(Hand Ranges 214-219)*.



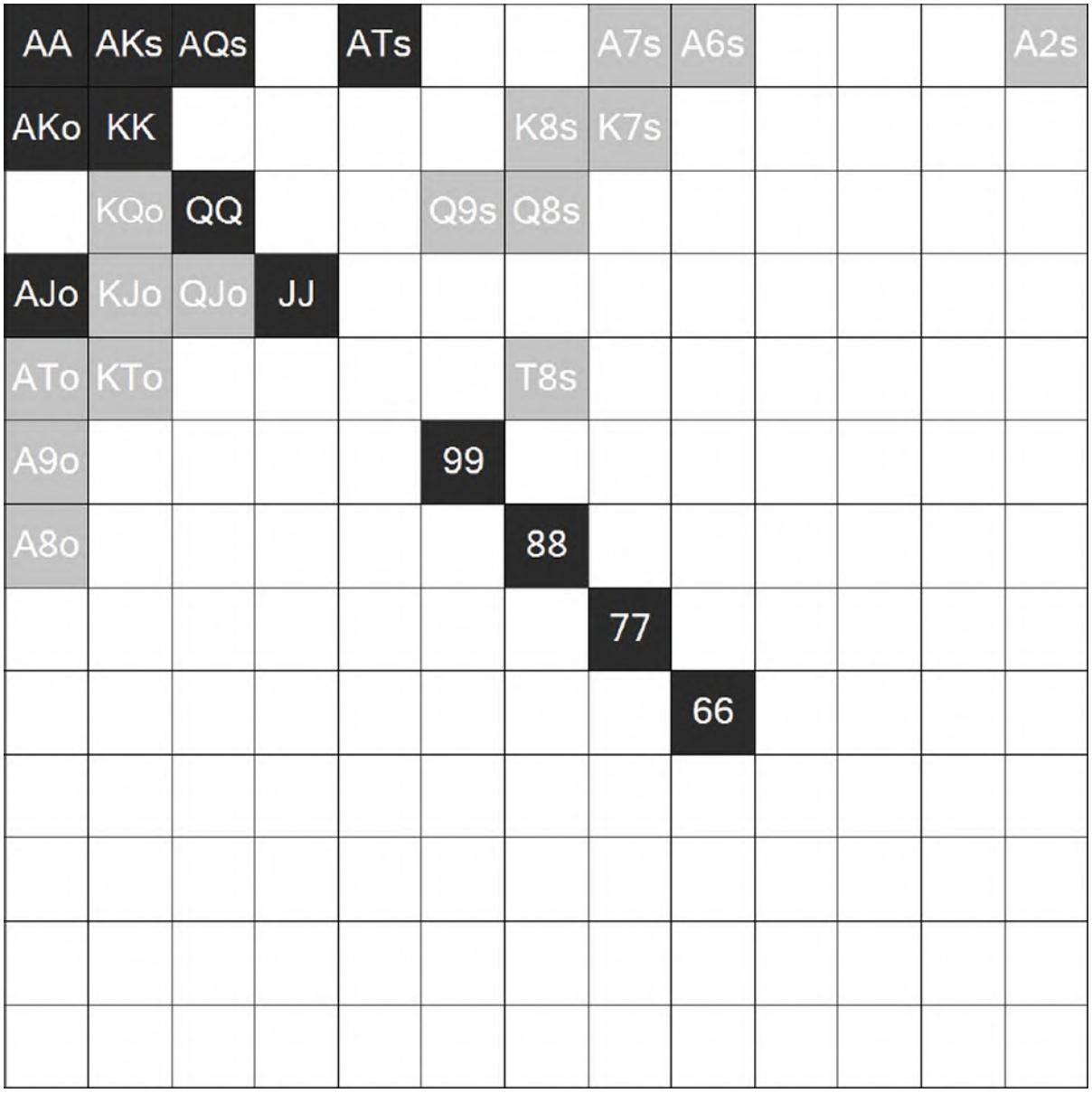
Hand Range 214: BN vs CO (25bb) • All-in 5.9% / • 3-bet 3% / • Call 13.5% / • Fold 77.5%



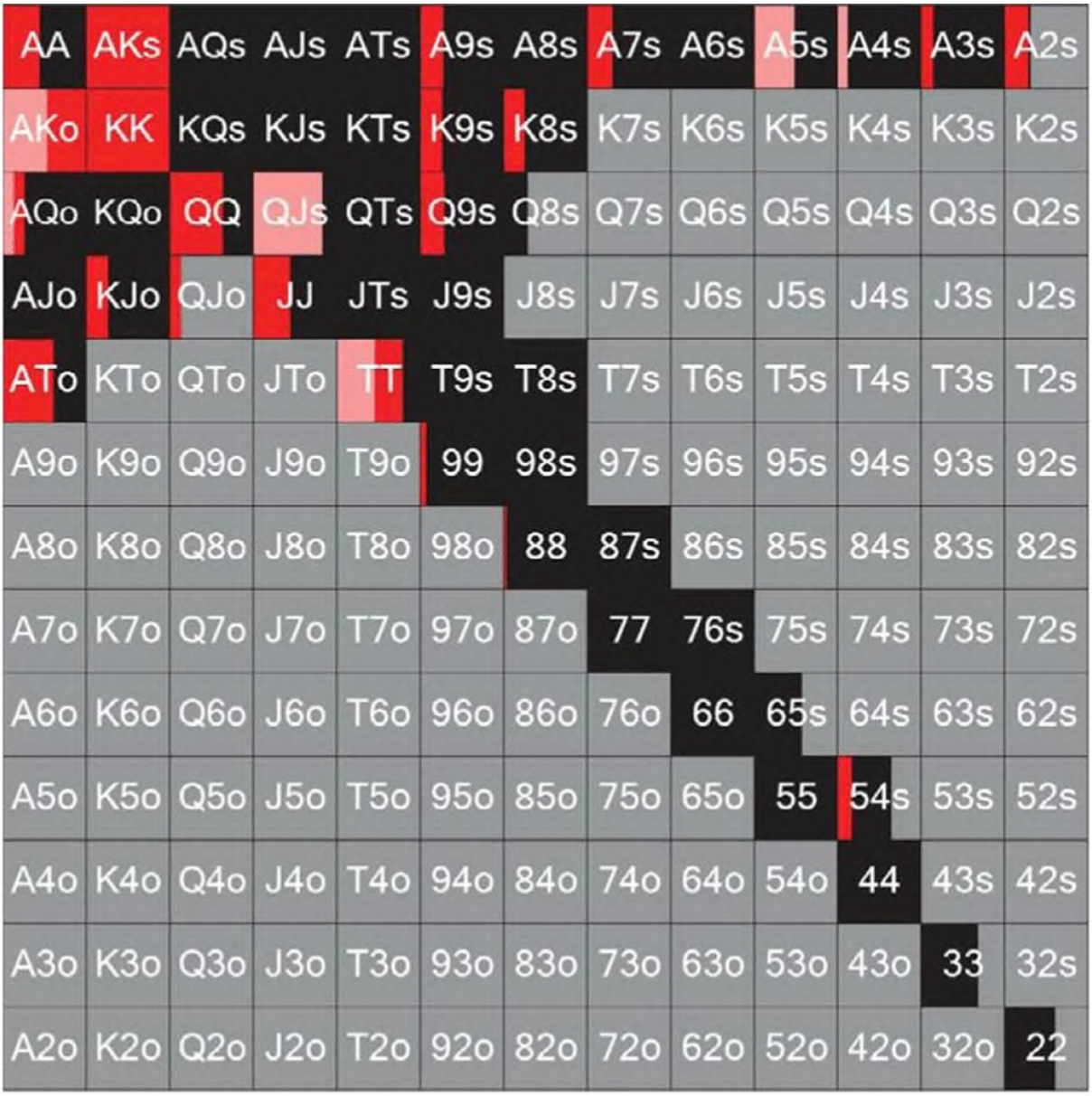
Hand Range 215: BN vs CO 4-bet (25bb) • Call 58.9% / • Fold 41.1%



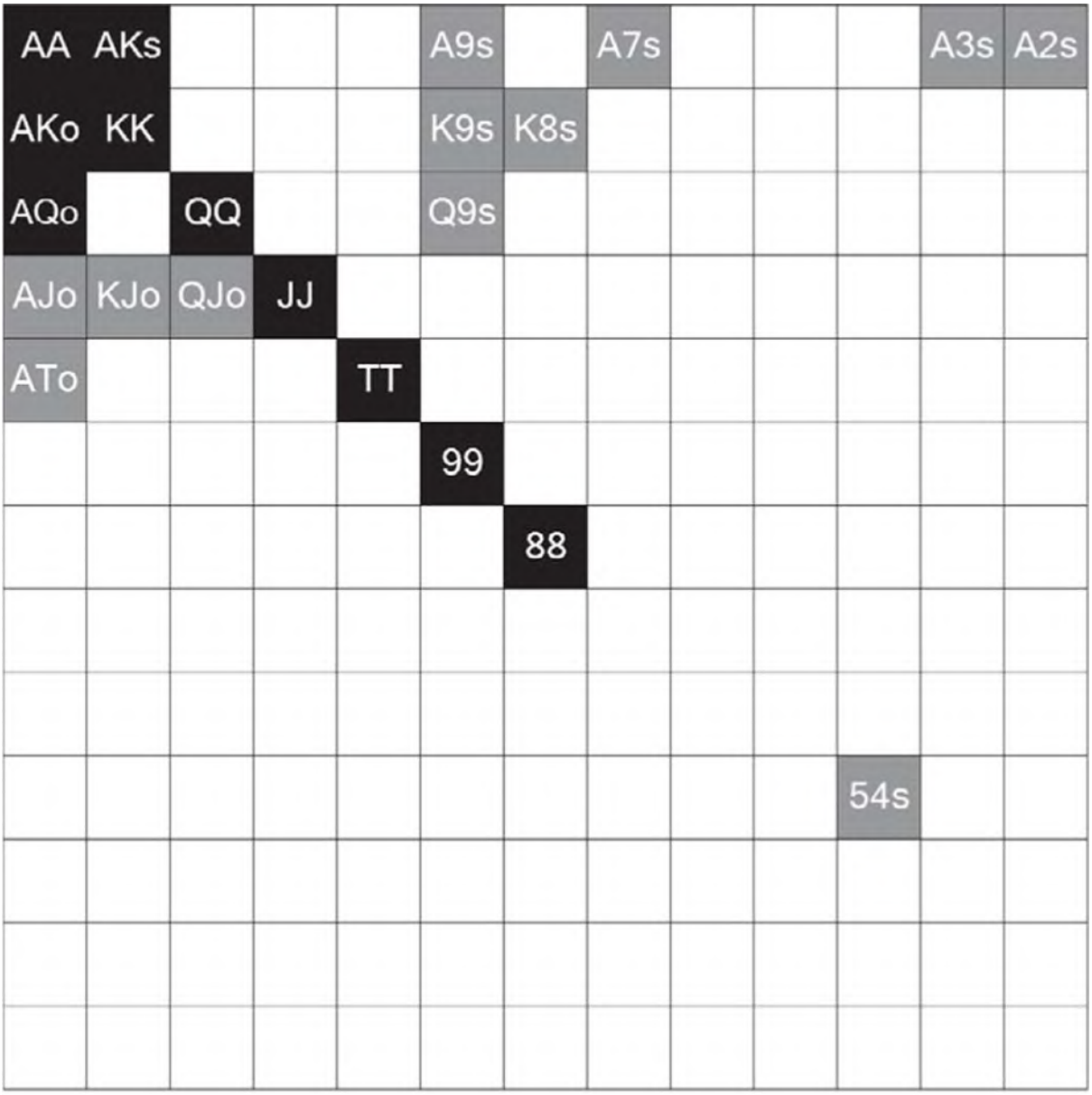
Hand Range 216: BN vs LJ (25bb) • All-in 3.5% / • 3-bet 3.5% / • Call 13.8% / • Fold 79.3%



Hand Range 217: BN vs LJ 4-bet (25bb) • Call 56.3% / • Fold 43.7%



Hand Range 218: BN vs UTG (25bb) • All-in 1.2% / • 3-bet 3.7% / • Call 14.6% / • Fold 80.5%



Hand Range 219: BN vs UTG 4-bet (25bb) • Call 59.3% / • Fold 40.7%

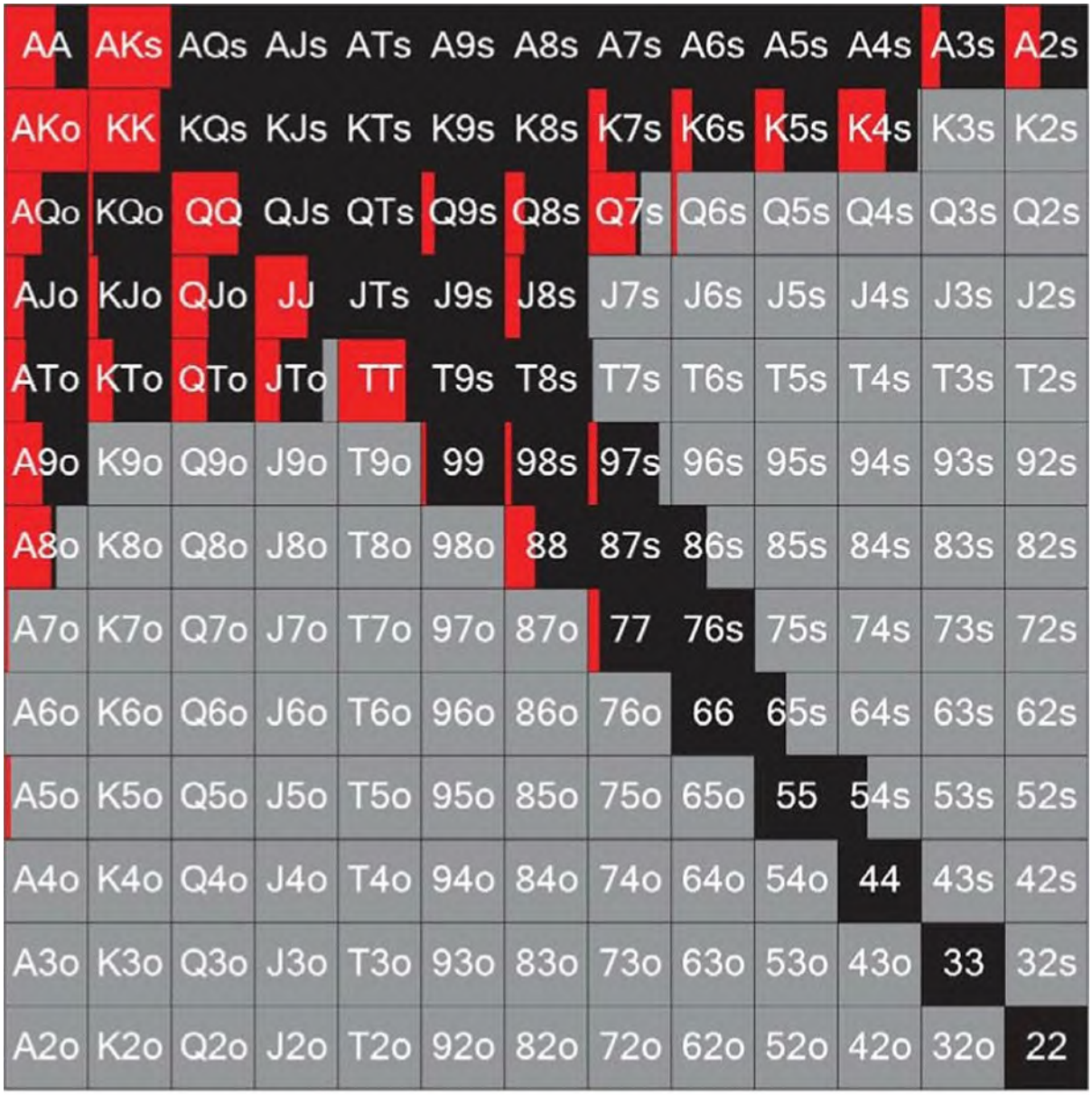
Defending the BN (40bb)

BN vs	3-bet	Call	Fold
CO	7.50%	19.60%	72.90%
HJ	6.90%	18.10%	75.00%
LJ	6.90%	16.90%	76.30%
UTG+2	5.60%	16.90%	77.40%
UTG+1	5.30%	16.00%	78.80%
UTG	5.20%	15.90%	78.90%
Average	6.23%	17.23%	76.55%

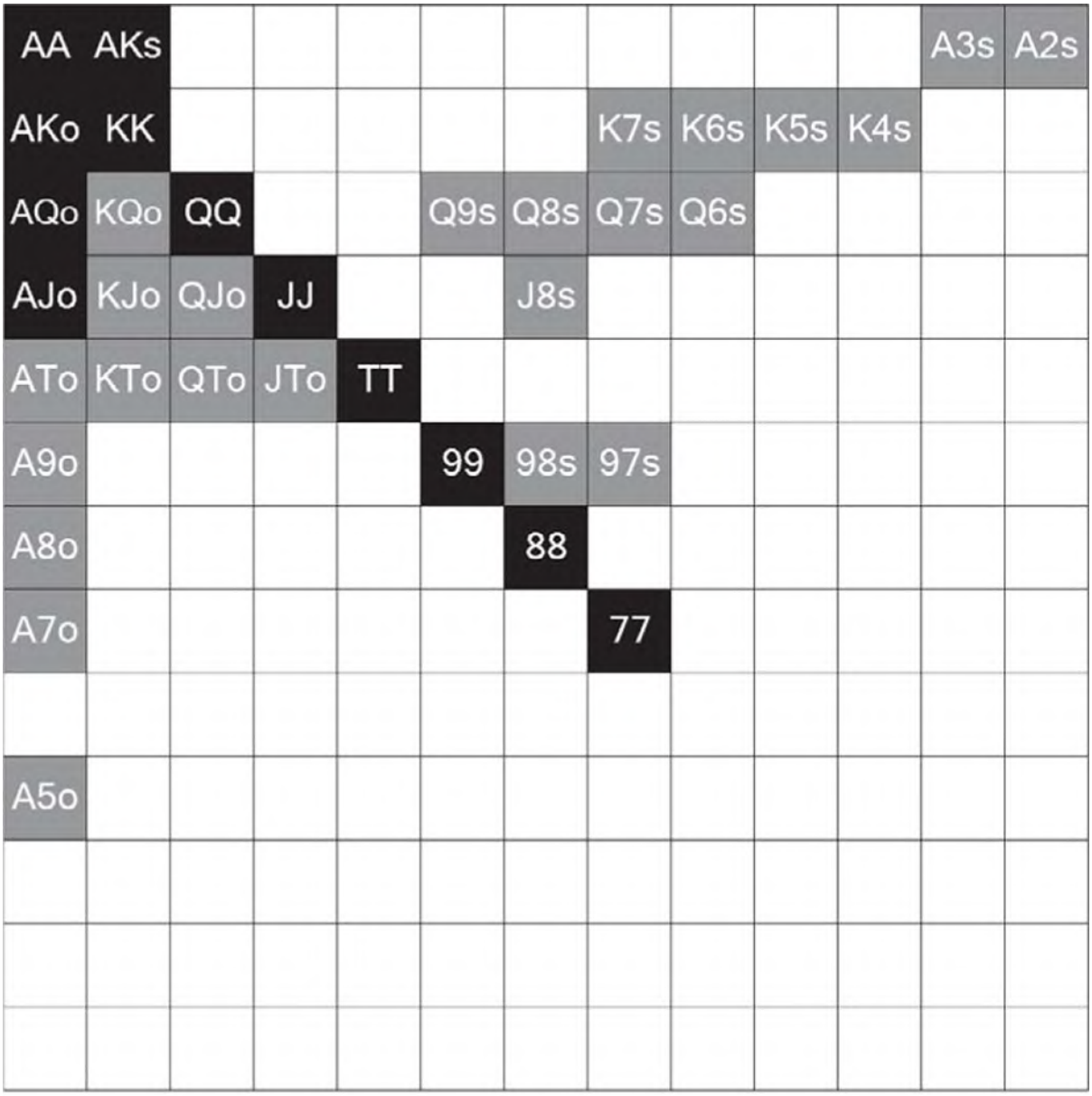
Table 69: BN Action Frequencies (40bb)

With 40bb, the BN has no all-in 3-betting range. The VPIP frequency increases depending on the opener's range strength, going from 21.1% vs UTG to 27.1% vs the CO. In this instance, both the 3-betting and the calling ranges increase in a linear fashion.

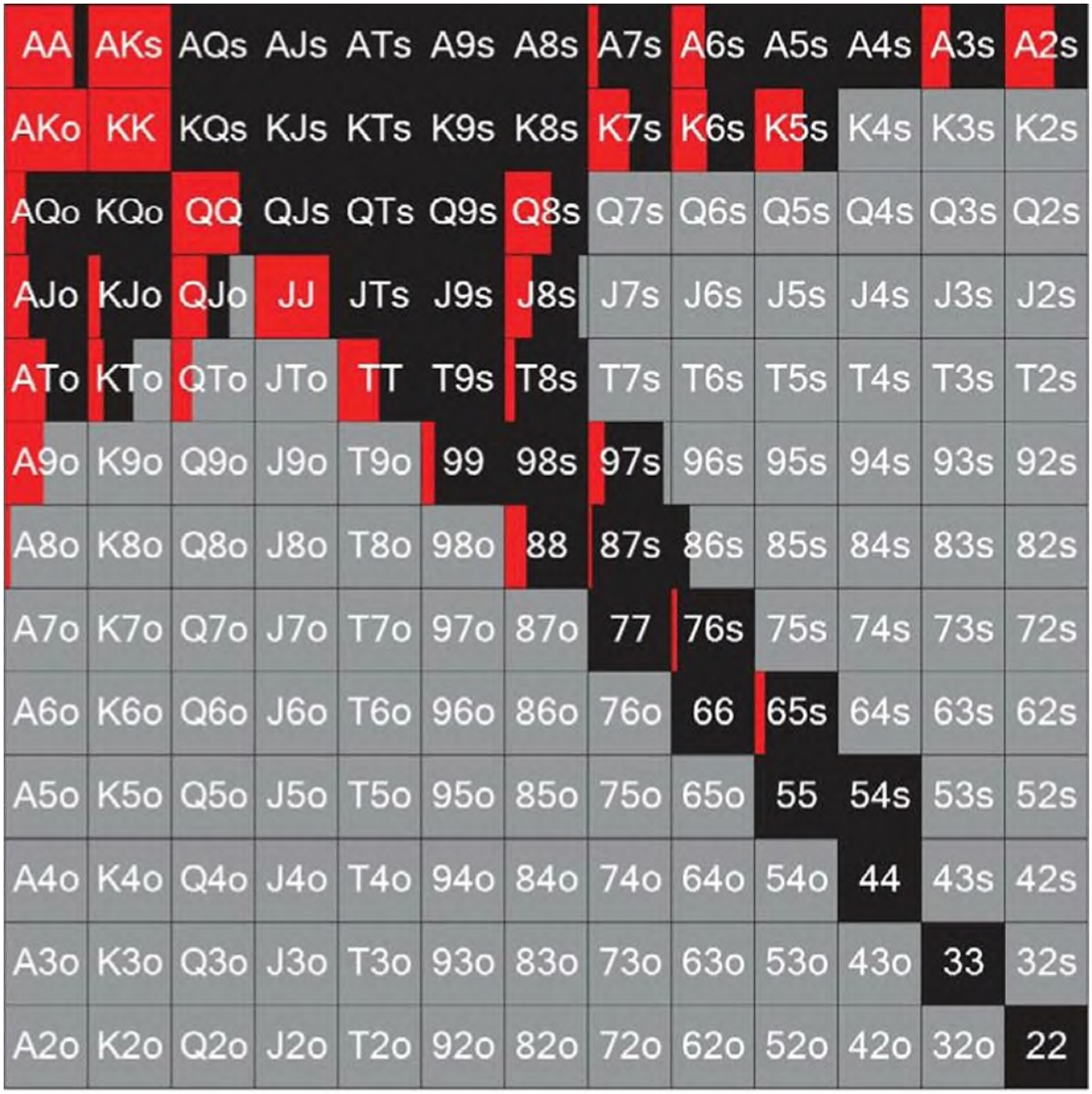
The 3-betting range is polarized, focusing on offsuit Ax with medium kickers and offsuit broadways vs LP and replacing those with suited Ax vs EP, with middle to low Kxs usually making great bluffing hands. The calling range includes middle to small pocket pairs, Axs, suited connectors and suited broadways and incorporates offsuit broadways vs LP *(Hand Ranges 220-225)*.



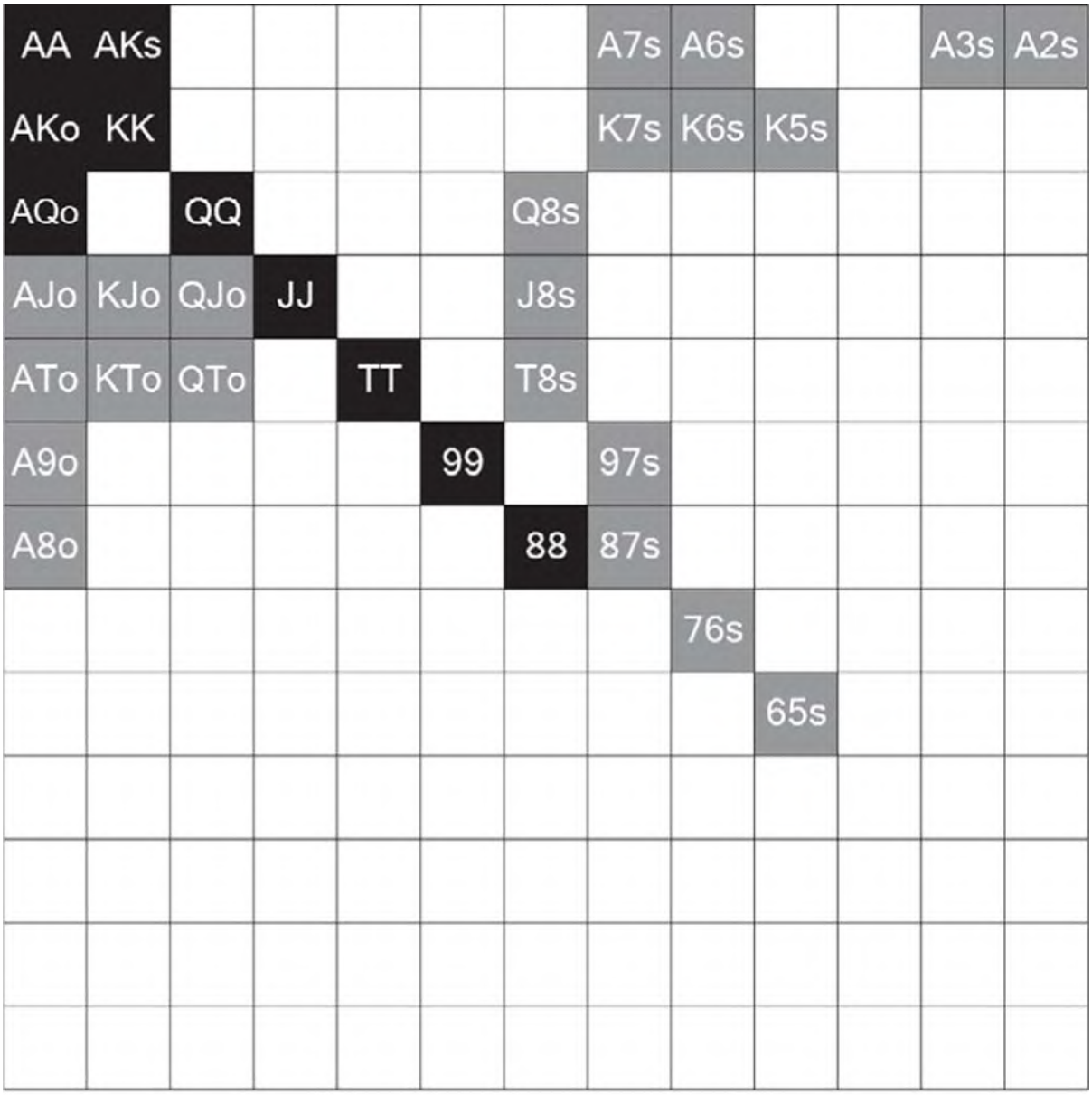
Hand Range 220: BN vs CO (40bb) • 3-bet 7.5% / • Call 19.6% / • Fold 72.9%



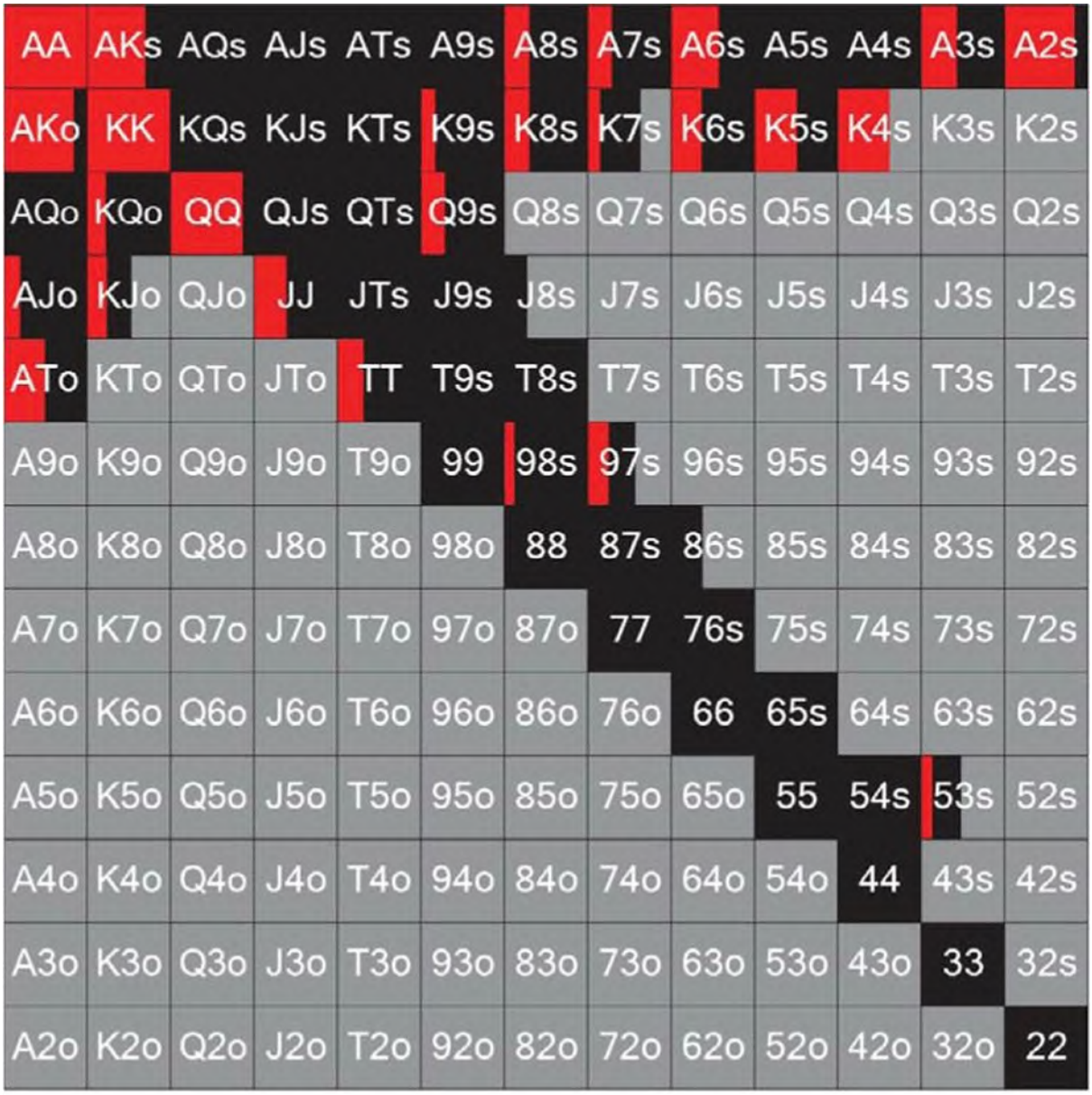
Hand Range 221: BN vs CO 4-bet (40bb) • Call 50.1% / • Fold 49.9%



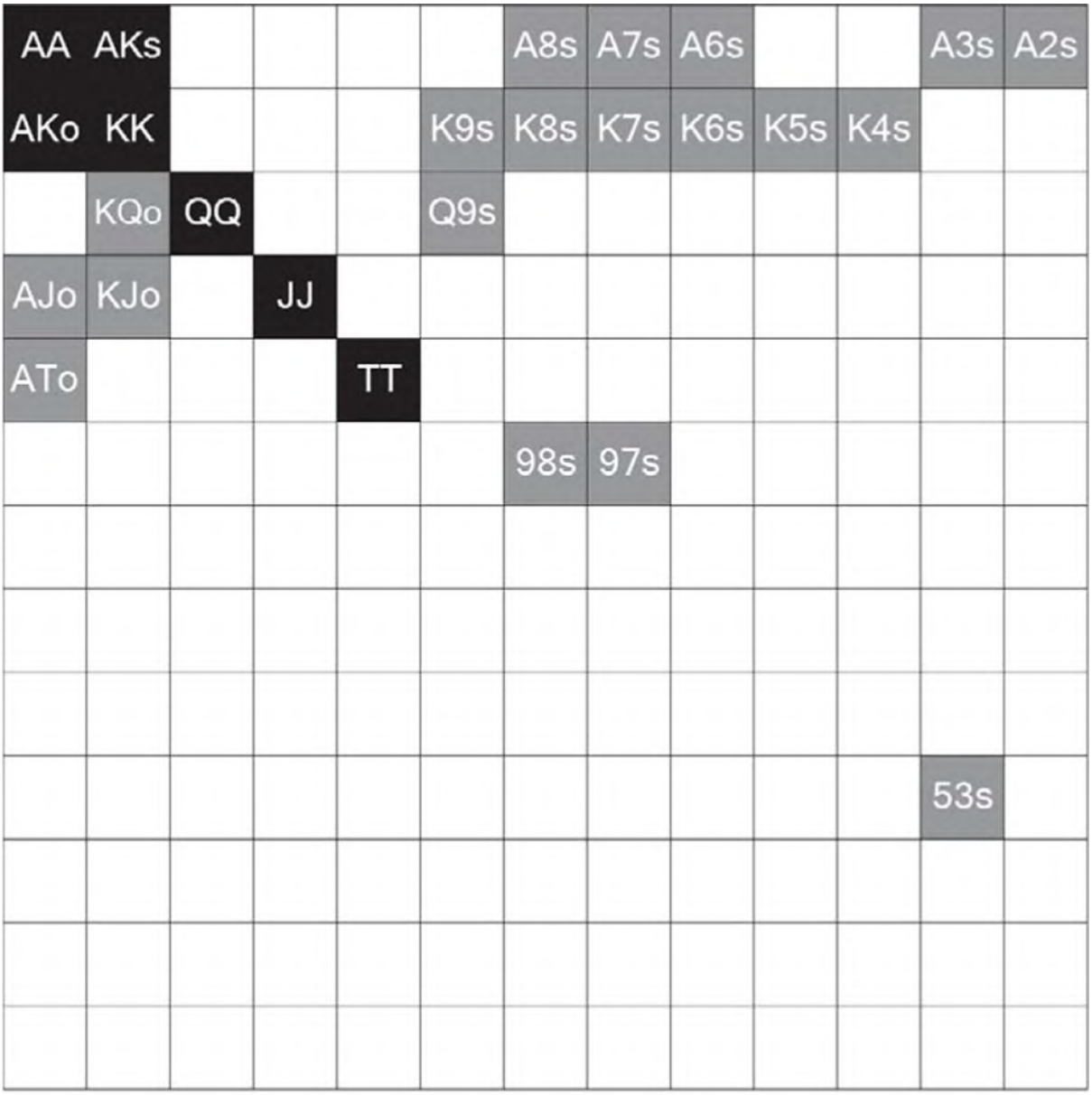
Hand Range 222: BN vs LJ (40bb) • 3-bet 6.9% / • Call 16.9% / • Fold 76.3%



Hand Range 223: BN vs LJ 4-bet (40bb) • Call 50.3% / • Fold 49.7%



Hand Range 224: BN vs UTG (40bb) • 3-bet 5.2% / • Call 15.9% / • Fold 78.9%



Hand Range 225: BN vs UTG 4-bet (40bb) • Call 49.6% / • Fold 50.4%

Defending the BN (60bb)

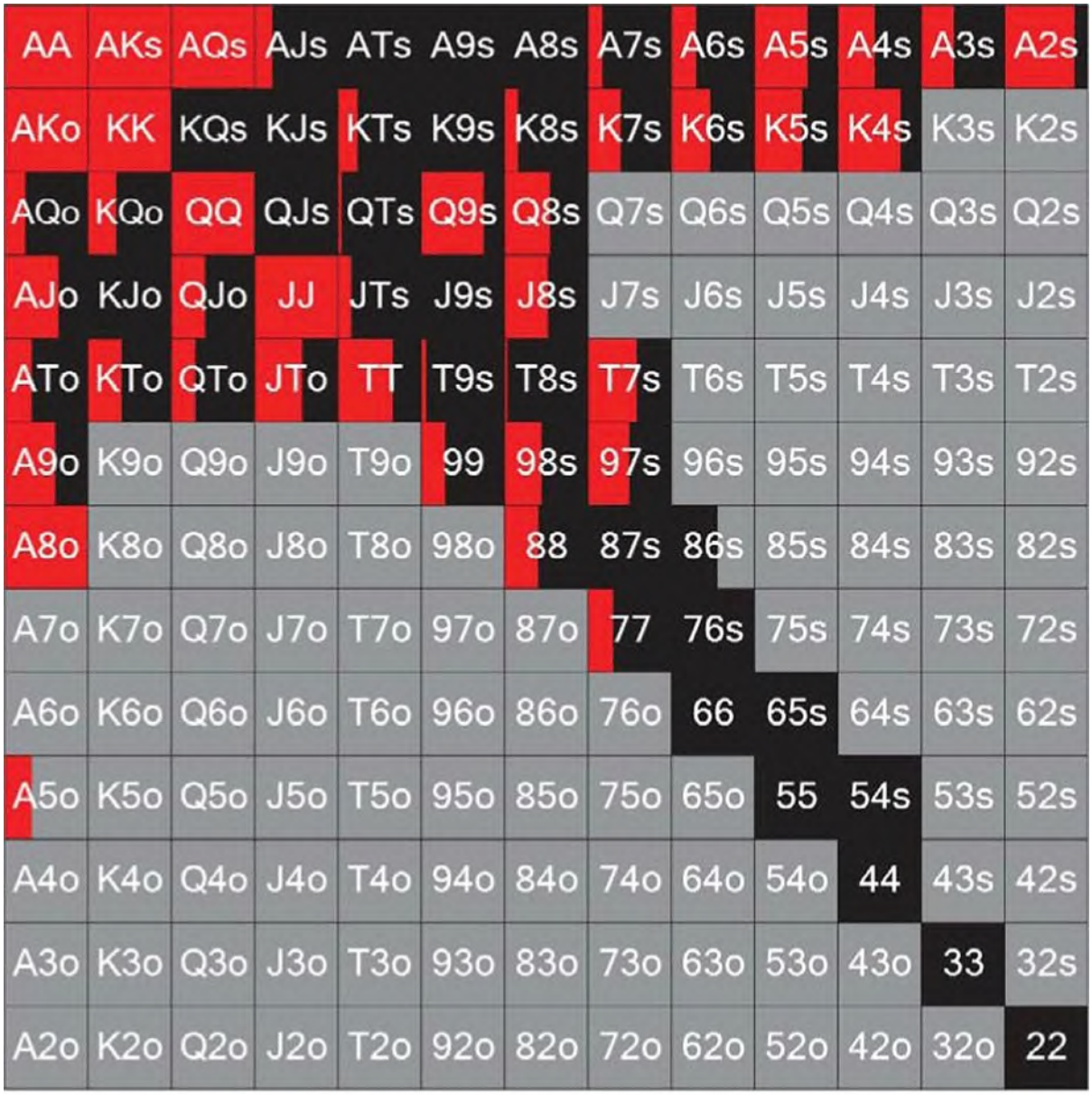
BN vs	3-bet	Call	Fold
CO	11.50%	16.90%	71.60%
HJ	9.50%	15.50%	75.00%
LJ	8.60%	15.60%	75.80%
UTG+2	6.30%	15.90%	77.90%
UTG+1	6.10%	16.10%	77.80%
UTG	5.50%	16.30%	78.30%
Average	7.92%	16.05%	76.07%

Table 70: BN Action Frequencies (60bb)

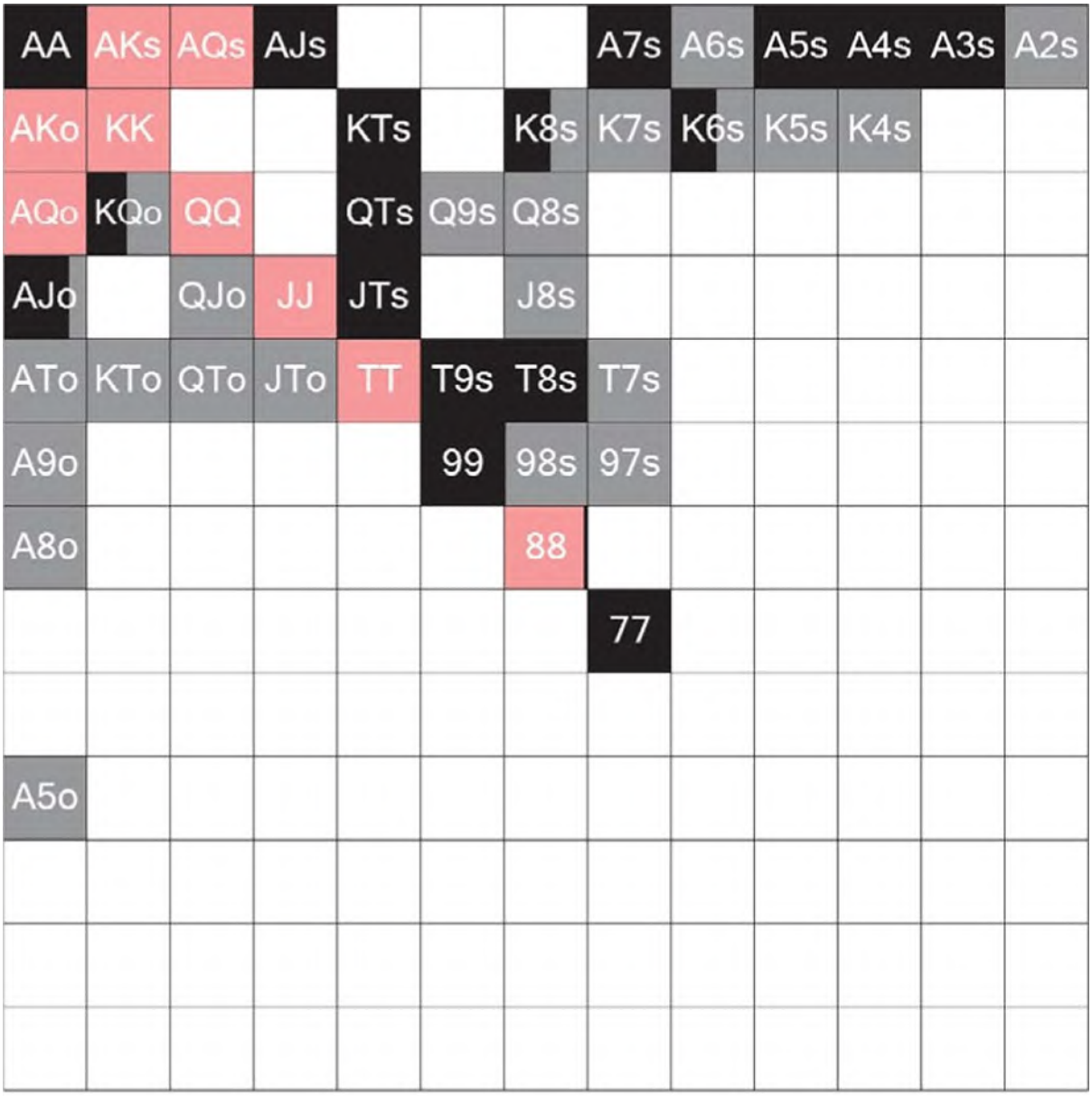
With 60bb the BN VPIP frequency maintains the same pattern as seen before, increasing as the opener range weakens. The calling frequency remains more or less constant, but the 3-betting frequency lowers as the opener's range gets stronger.

The BN 3-betting range is very polarized, but given stacks allow for post-flop play you still don't want to be 3-betting a lot of trash and having to play post-flop deep-stacked with very low equity hands against a strong range.

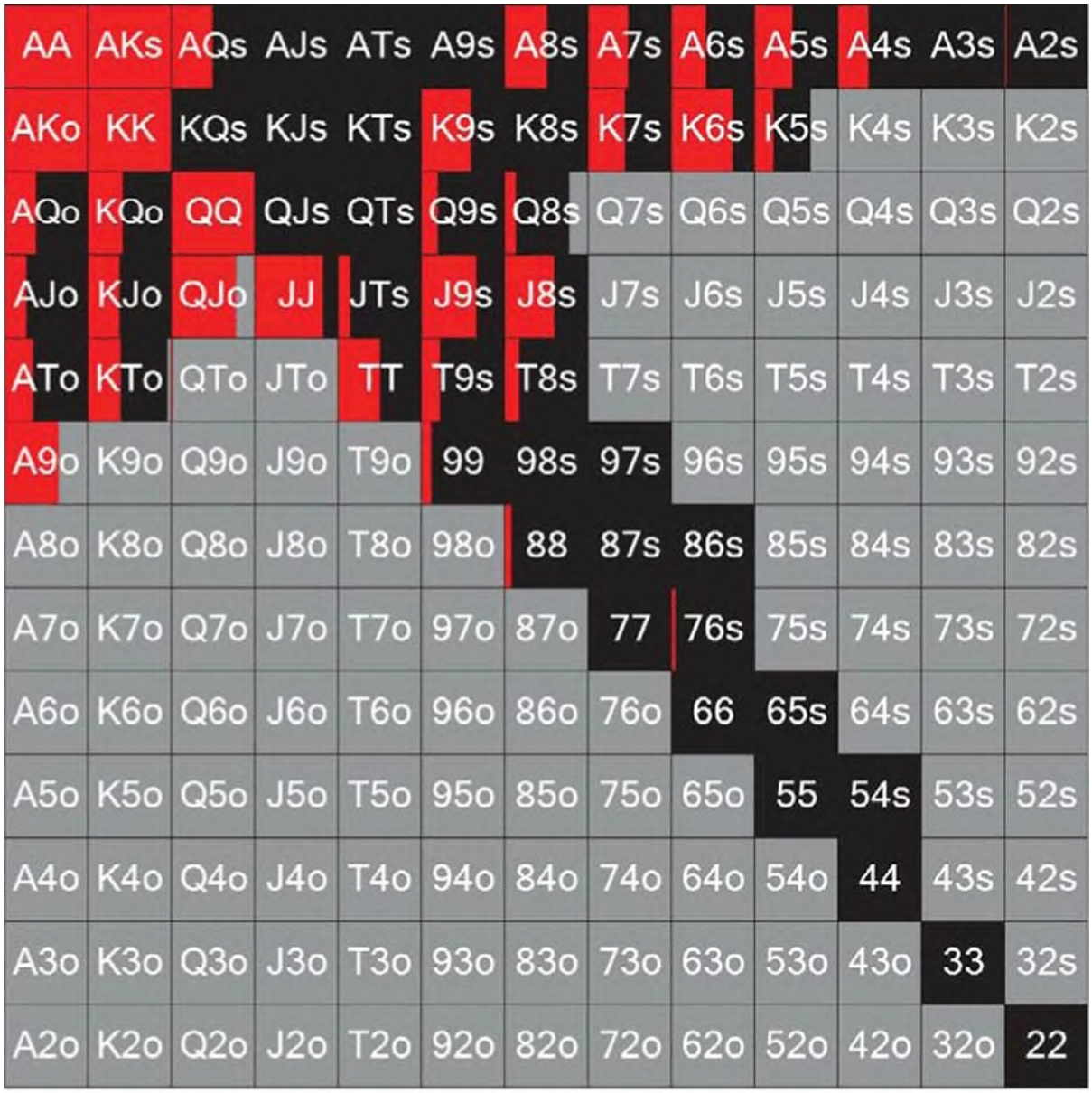
The BN 60bb calling range will maintain a similar shape to the 40bb range, flatting a lot of pocket pairs, suited connectors and suited broadways *(Hand Ranges 226-231)*.



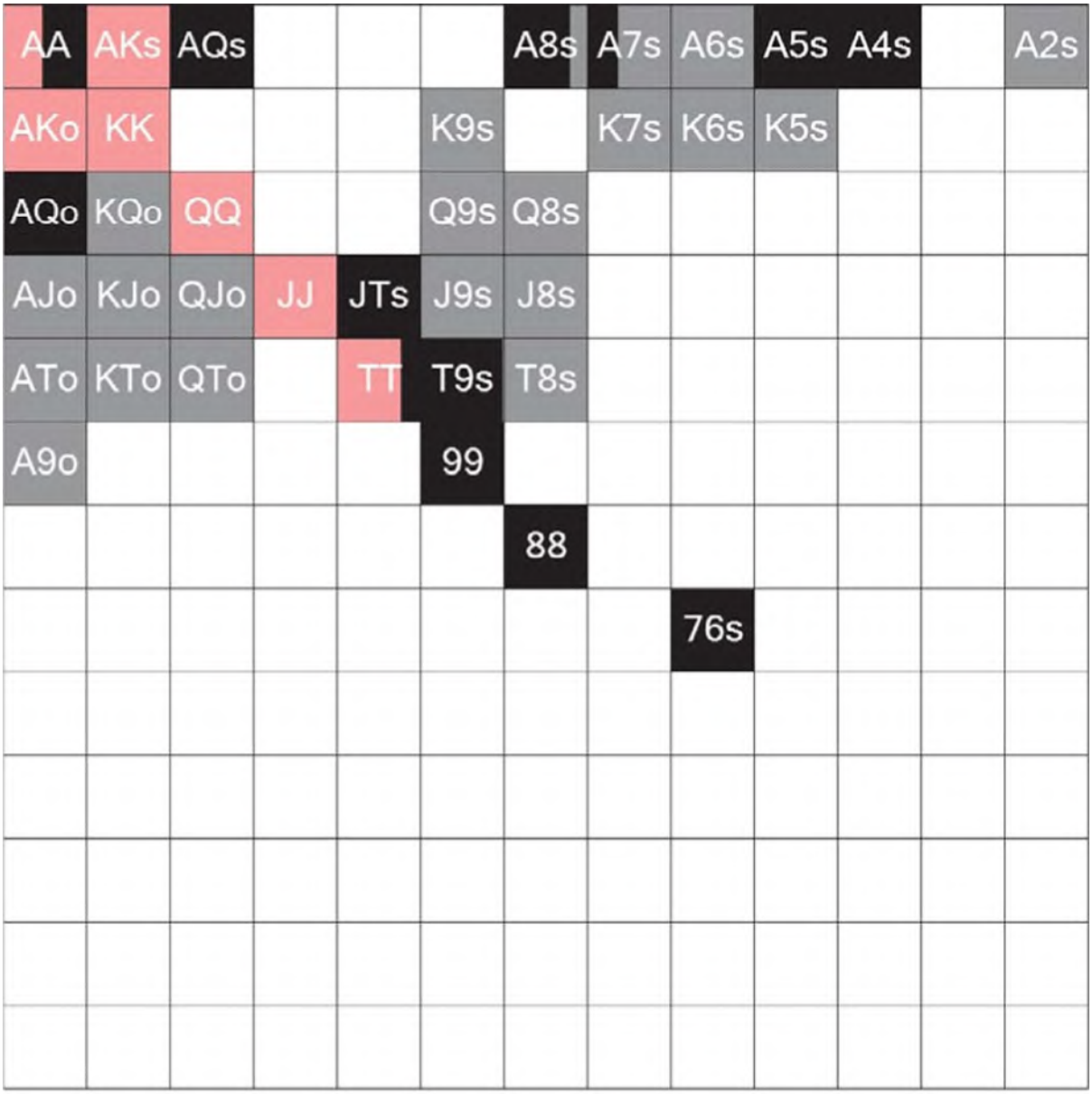
Hand Range 226: BN vs CO (60bb) • 3-bet 11.5% / • Call 16.9% / • Fold 71.6%



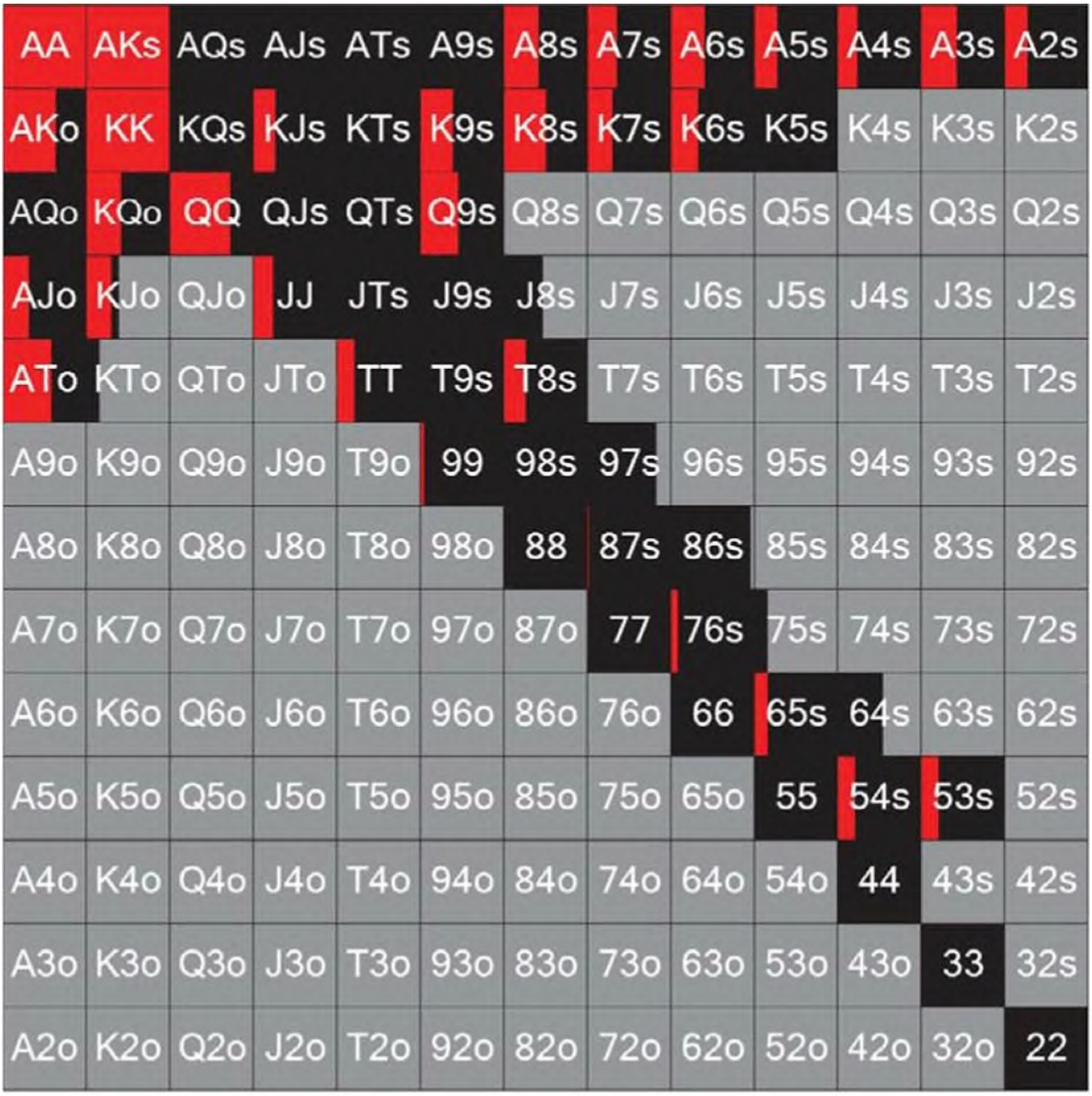
Hand Range 227: BN vs CO 4-bet (60bb) • All-in 31.1% / • Call 18.7% / • Fold 50.3%



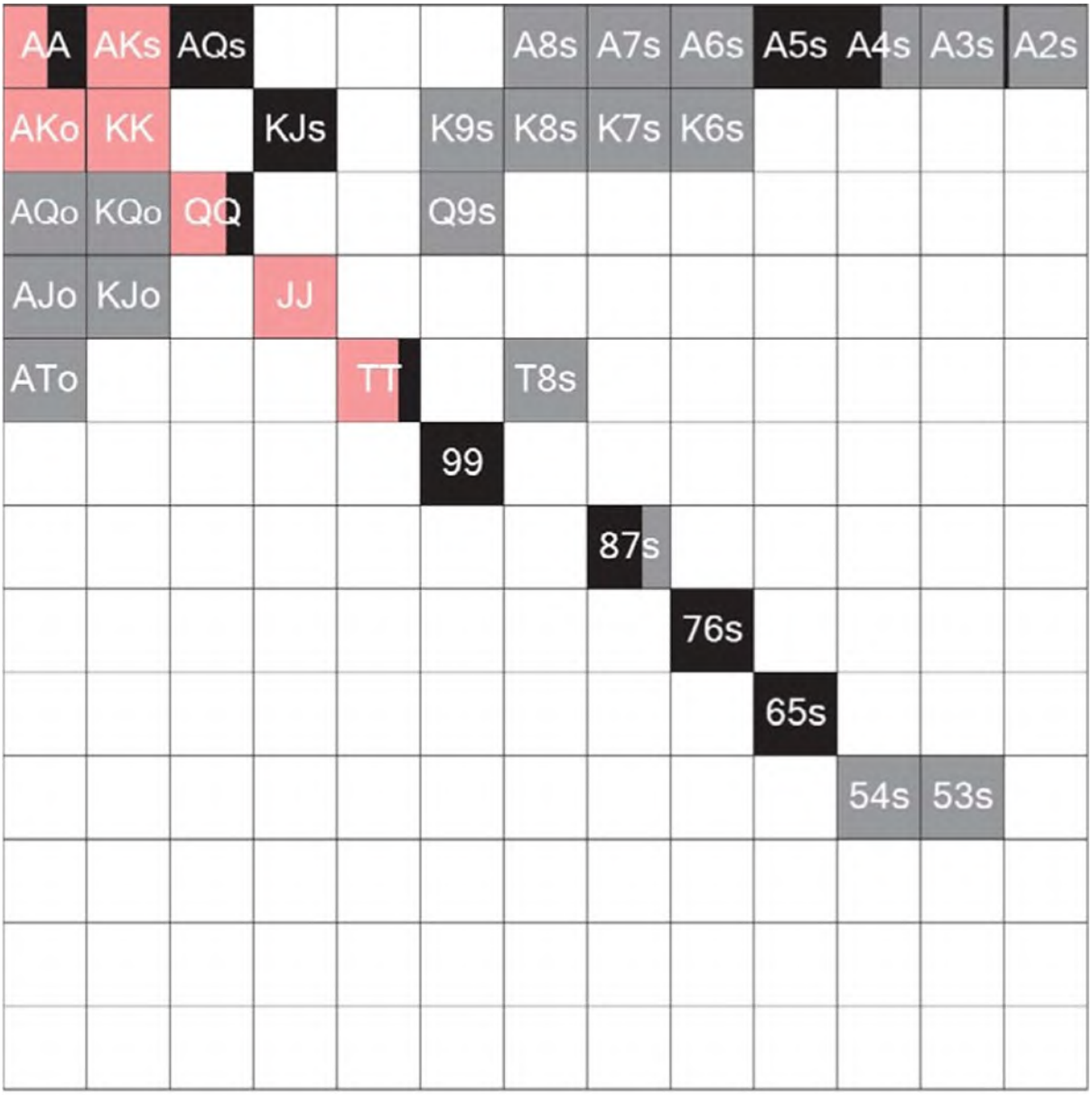
Hand Range 228: BN vs LJ (60bb) • 3-bet 8.6% / • Call 15.6% / • Fold 75.8%



Hand Range 229: BN vs LJ 4-bet (60bb) • All-in 33.5% / • Call 16.5% / • Fold 50.1%



Hand Range 230: BN vs UTG (60bb) • 3-bet 5.5% / • Call 16.3% / • Fold 78.3%



Hand Range 231: BN vs UTG 4-bet (60bb) • All-in 35.8% / • Call 11.7% / • Fold 52.4%

Defending the Cutoff

Defending the CO (15bb)

CO Versus	All-in	Fold
HJ	13.30%	86.70%
LJ	11.70%	88.30%
UTG+2	10.40%	89.60%
UTG+1	9.70%	90.30%
UTG	8.30%	91.70%
Average	10.68%	89.32%

Table 71: CO Action Frequencies (15bb)

With 15bb, the CO has no flatting range because, unlike the BN, the CO has to worry about the BN calling or squeezing behind him. Splitting the CO's range represents a higher risk so, with 15bb, the best way to approach this situation is to simply rejam the entire playable range, increasing from 8.3% vs UTG (rejamming 66+, AJo+, ATs+, KTs+, QJs) to 13.3% vs the HJ (adding A9s, A5s, ATo and KQo) *(Hand Ranges 232-233)*.

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

Hand Range 232: CO vs LJ (15bb) • All-in 11.7% / • Fold 88.3%

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

Hand Range 233: CO vs UTG (15bb) • All-in 8.3% / • Fold 88.7%

Defending the CO (25bb)

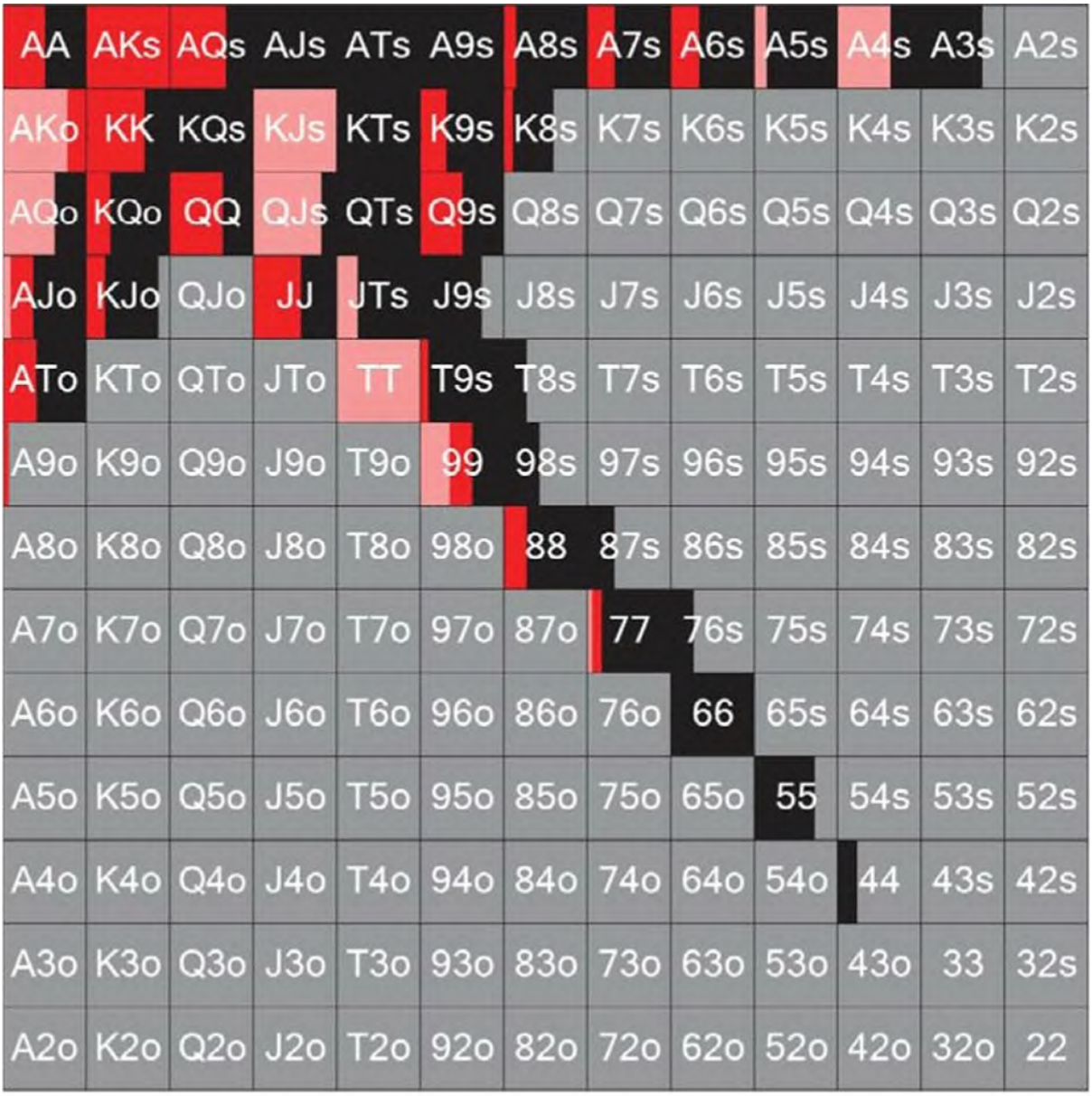
CO Versus	All-in	3-bet	Call	Fold
HJ	3.80%	2.90%	10.90%	82.50%
LJ	2.80%	3.80%	10.00%	83.10%
UTG+2	1.90%	4.00%	10.10%	84.00%
UTG+1	1.70%	4.00%	9.70%	84.60%
UTG	1.20%	4.20%	9.70%	85.00%
Average	2.28%	3.78%	10.08%	83.84%

Table 72: CO Action Frequencies (25bb)

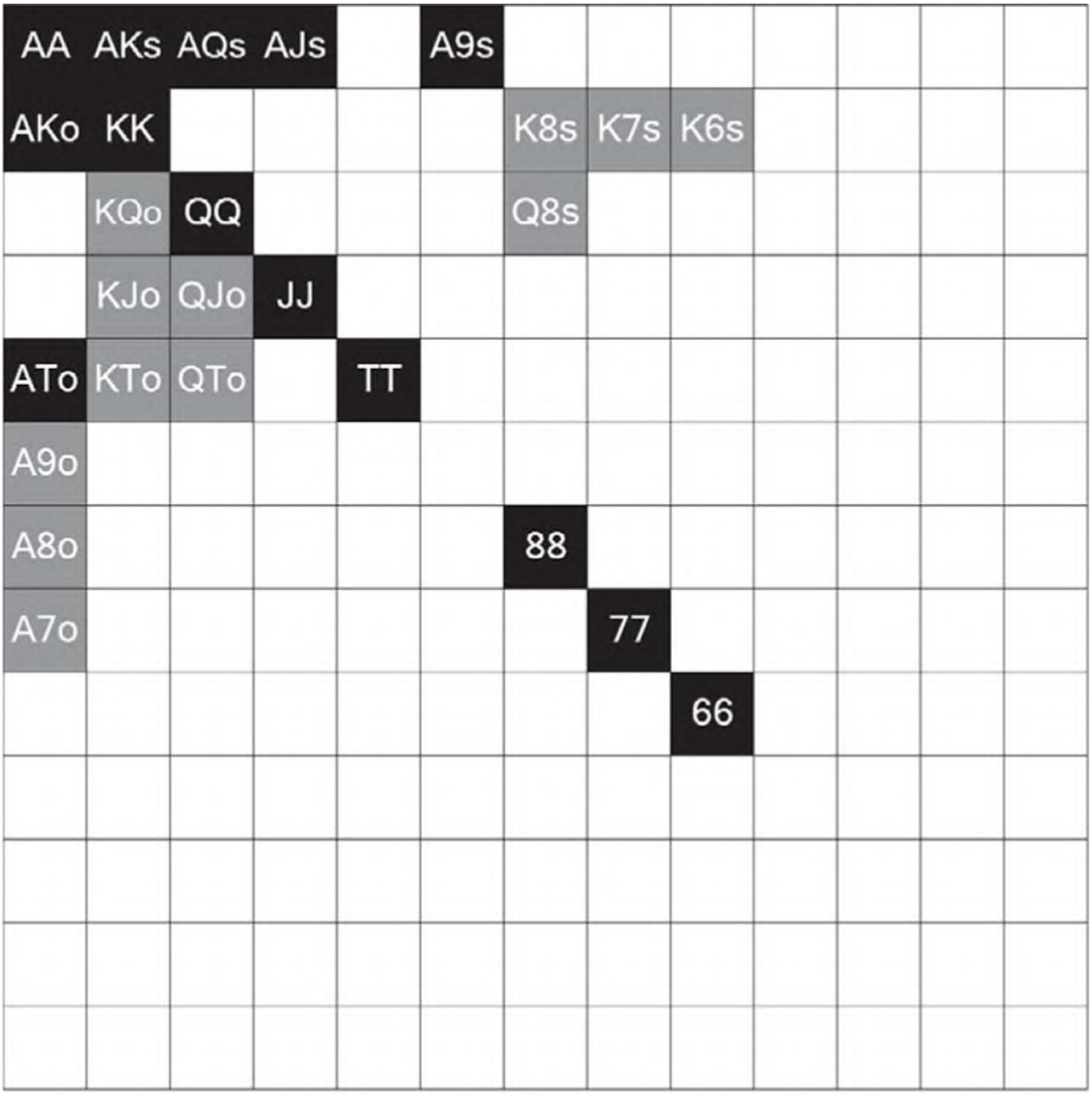
With 25bb, the CO rejams a narrow range so, in practice, I prefer scrapping it and playing a 3-bet/call/fold strategy instead.

The CO 3-bets non-all-in an average of 3.78% hands. This range is also quite narrow and polarized. The CO flats 10.08% on average with a capped range including mid to small pairs, suited broadways, ATo+ and KJo+

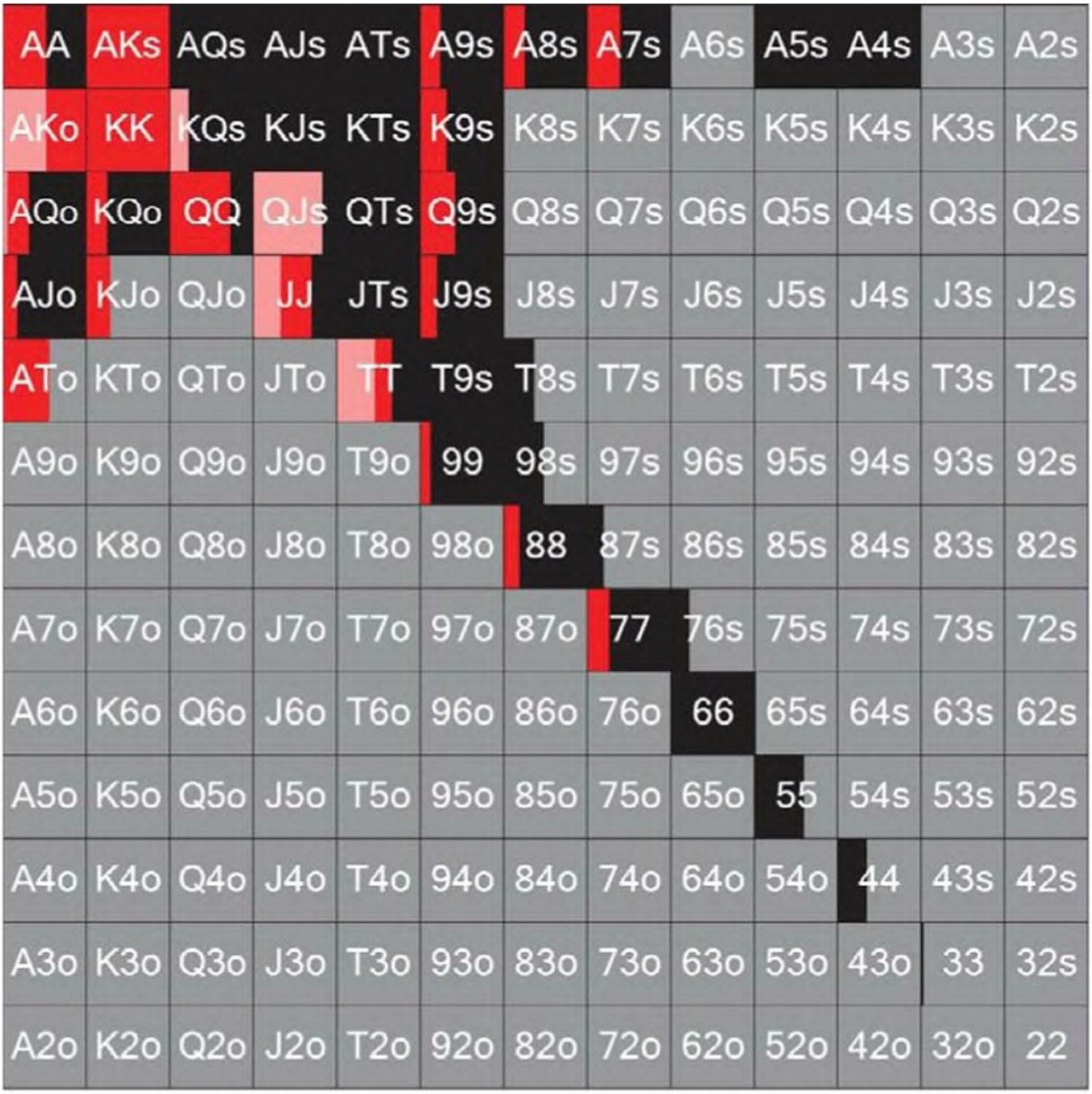
Flatting a capped range is not a big problem because the CO gains protection from the strength of the opener's range. It is important to notice how the CO's flatting range remains fairly constant. Unlike the BN, the CO has to worry about having to play OOP post-flop, and that limits the number of hands that can be peeled even vs wide ranges *(Hand Ranges 234-237)*.



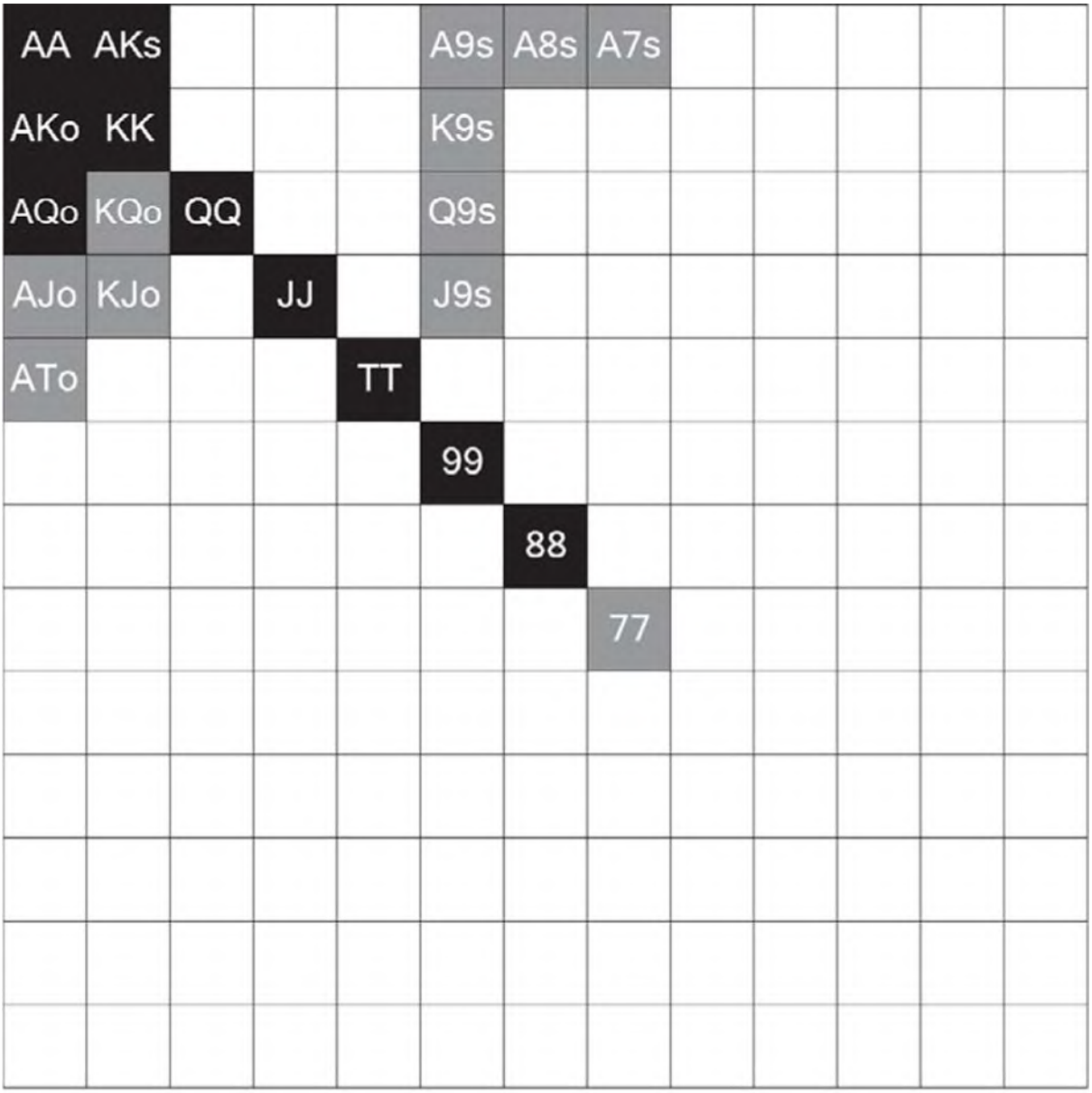
Hand Range 234: CO vs LJ (25bb) • All-in 2.8% / • 3-bet 3.8% / • Call 10% / • Fold 83.4%



Hand Range 235: CO vs LJ 4-bet (25bb) • Call 59.7% / • Fold 40.3%



Hand Range 236: CO vs UTG (25bb) • All-in 1.2% / • 3-bet 4.2% / • Call 9.7% / • Fold 85%



Hand Range 237: CO vs UTG 4-bet (25bb) • Call 57.2% / • Fold 42.8%

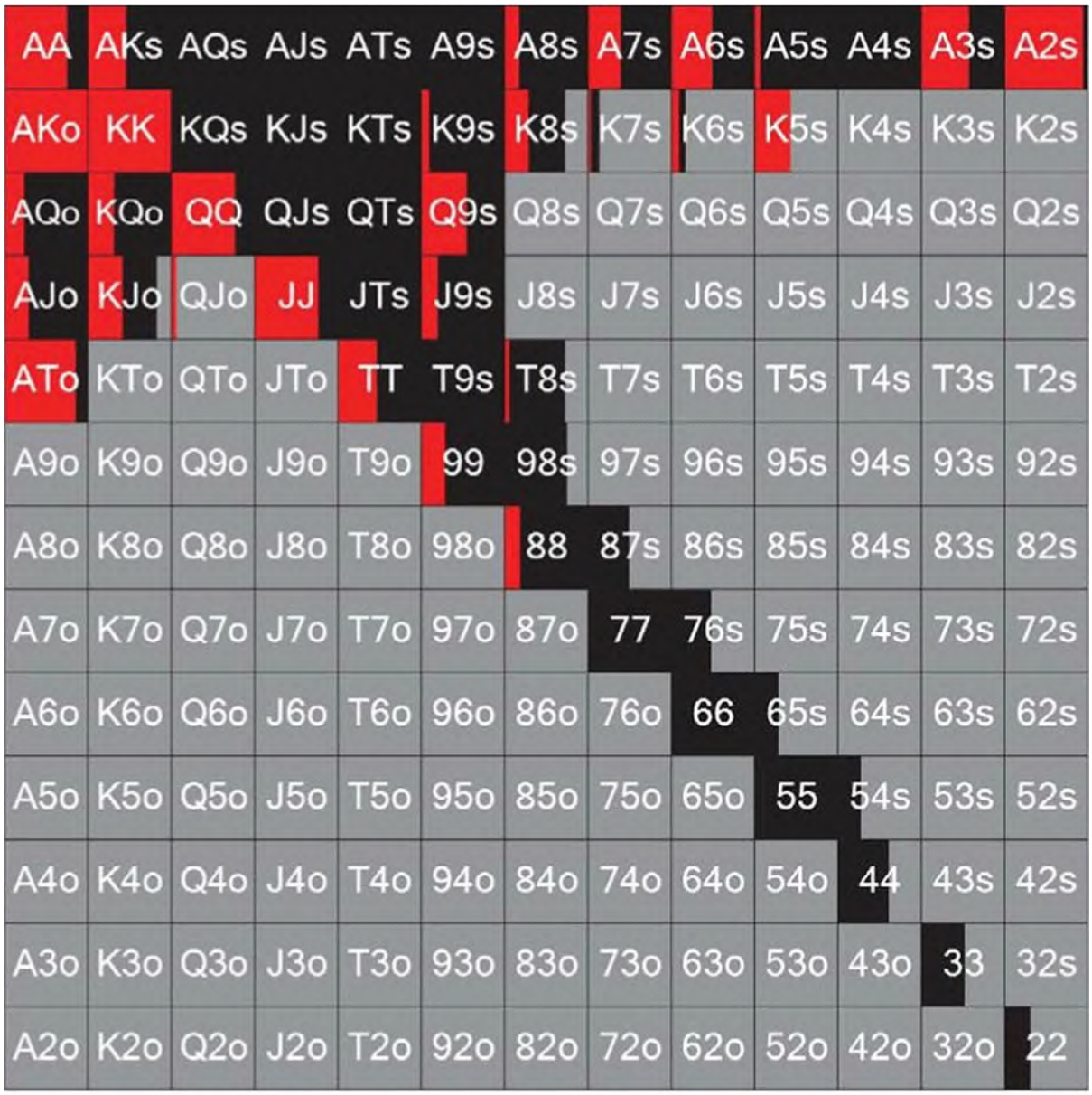
Defending the CO (40bb)

CO Versus	3-bet	Call	Fold
HJ	6.70%	13.30%	80.00%
LJ	6.20%	12.30%	81.50%
UTG+2	5.40%	13.20%	81.40%
UTG+1	5.00%	12.80%	82.20%
UTG	4.90%	12.80%	82.30%
Average	5.64%	12.88%	81.48%

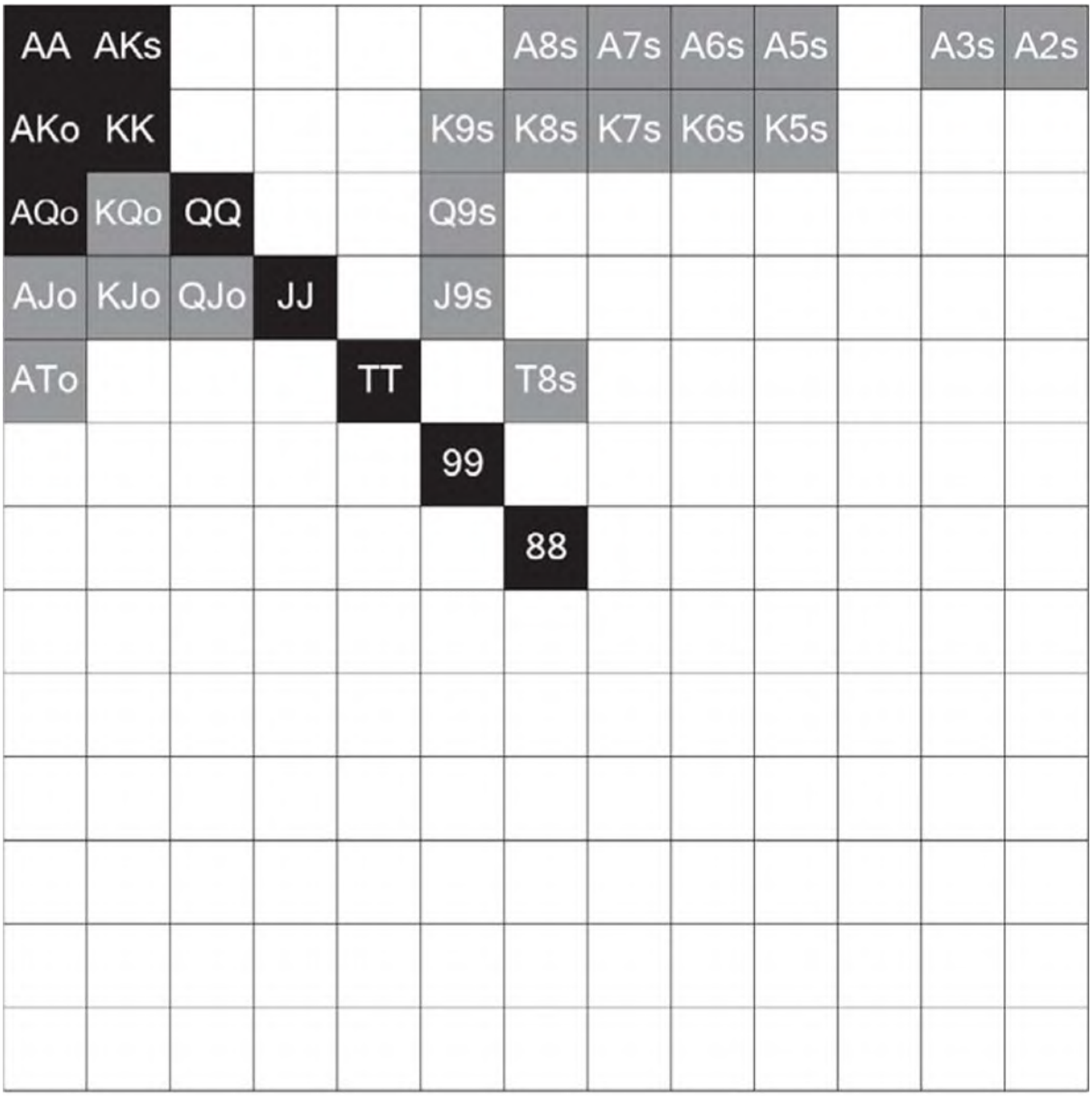
Table 73: CO Action Frequencies (40bb)

With 40bb, the CO plays a 3-bet/call/fold strategy. The 3-betting range is polarized; 3-betting 4.9% vs UTG and increasing the frequency to 6.7% vs the HJ. The best bluffing hands are mid to low suited Ax and Kx, AJo, ATo, and KQo, incorporating KJo and K9s-J9s as well as widening the value range to 88+ and AQo+ vs wider ranges.

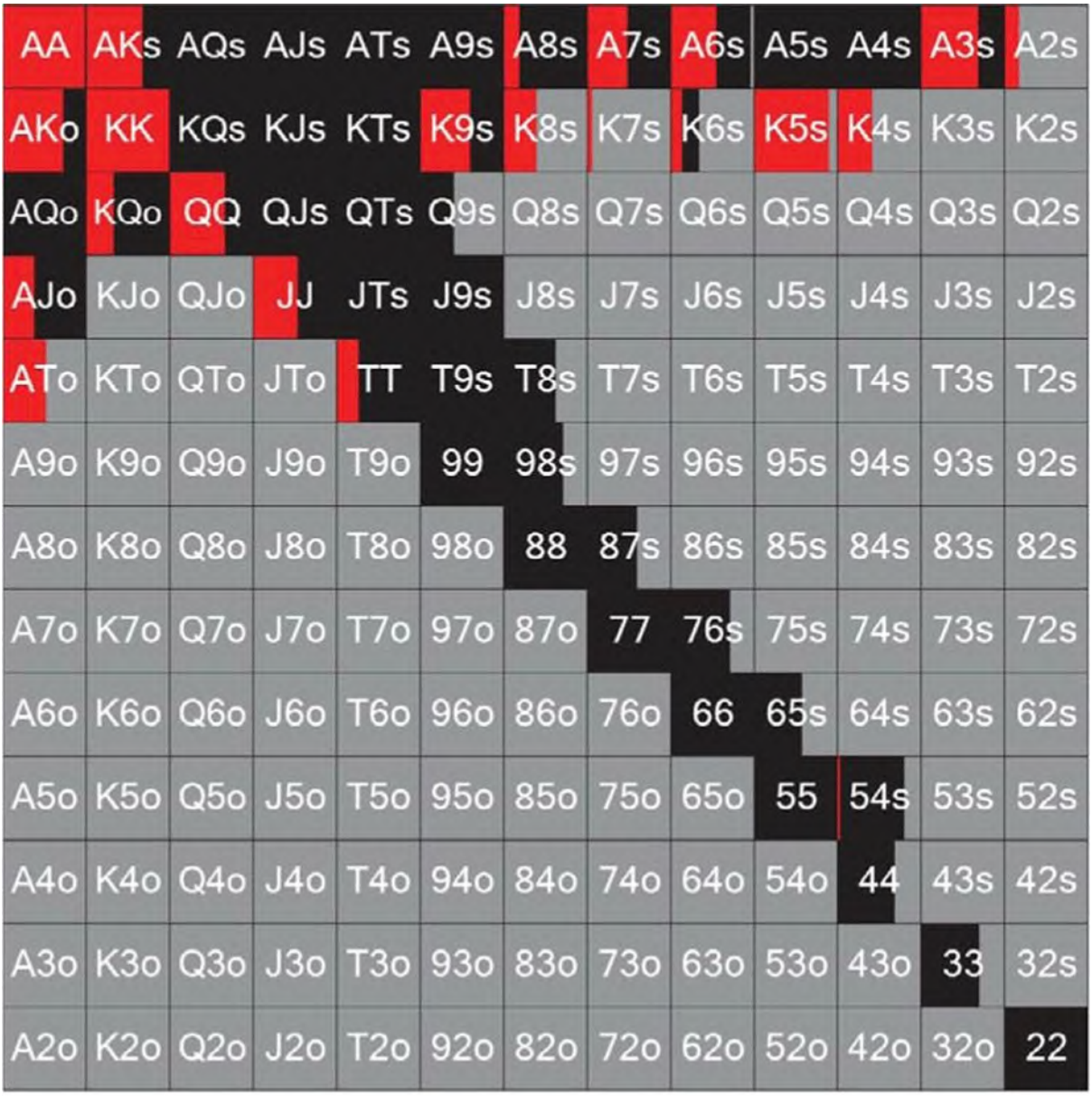
The flat-calling range mostly consists of mid to small pocket pairs, suited Ax, suited broadways and premium suited connectors, slow playing AA and AKs from time to time *(Hand Ranges 238-241)*.



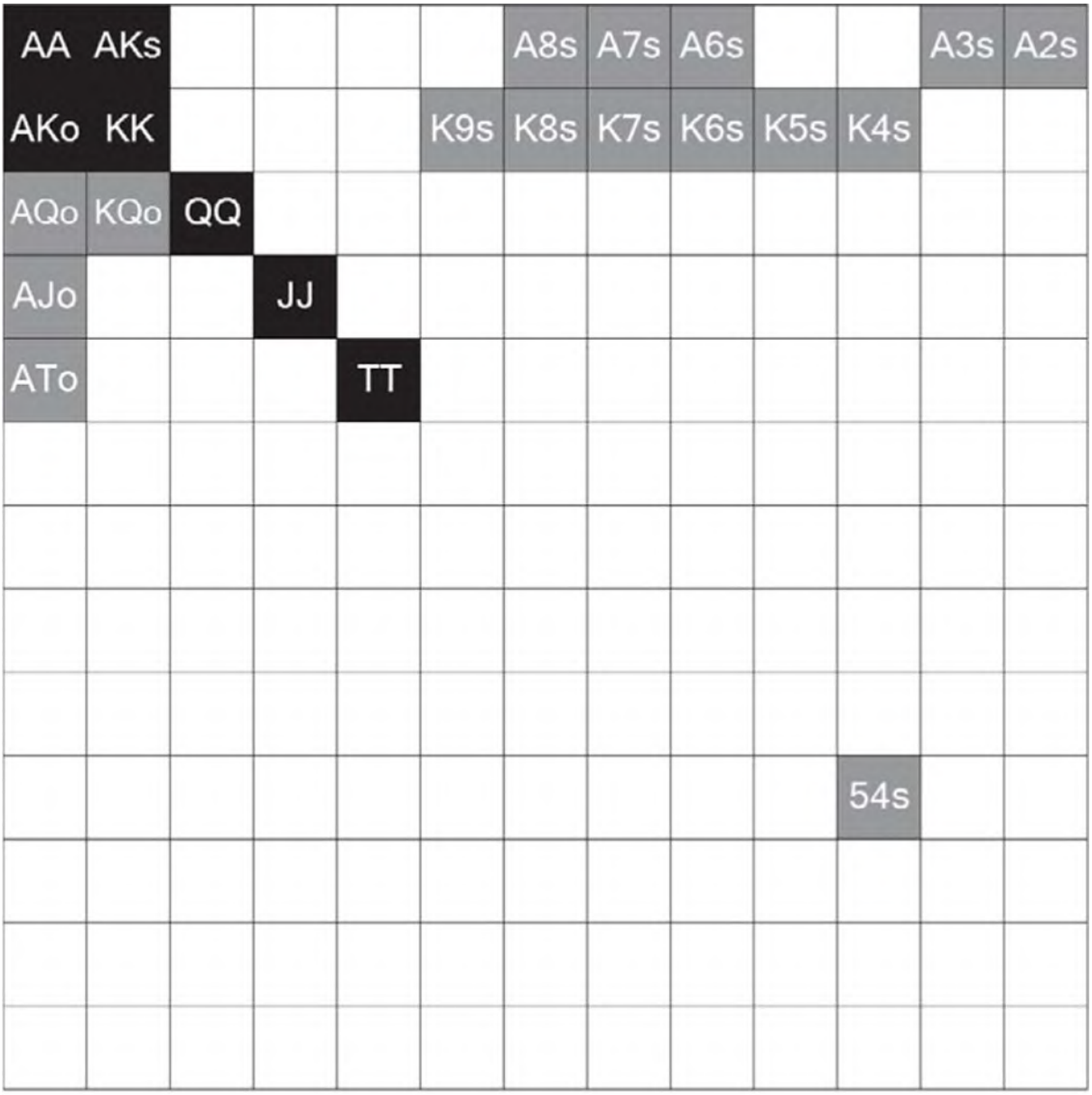
Hand Range 238: CO vs LJ (40bb) • 3-bet 6.2% / • Call 12.3% / • Fold 81.5%



Hand Range 239: CO vs LJ 4-bet (40bb) • Call 50.9% / • Fold 49.1%



Hand Range 240: CO vs UTG (40bb) • 3-bet 4.9% / • Call 12.8% / • Fold 82.3%



Hand Range 241: CO vs UTG 4-bet (40bb) • Call 49.9% / • Fold 50.8%

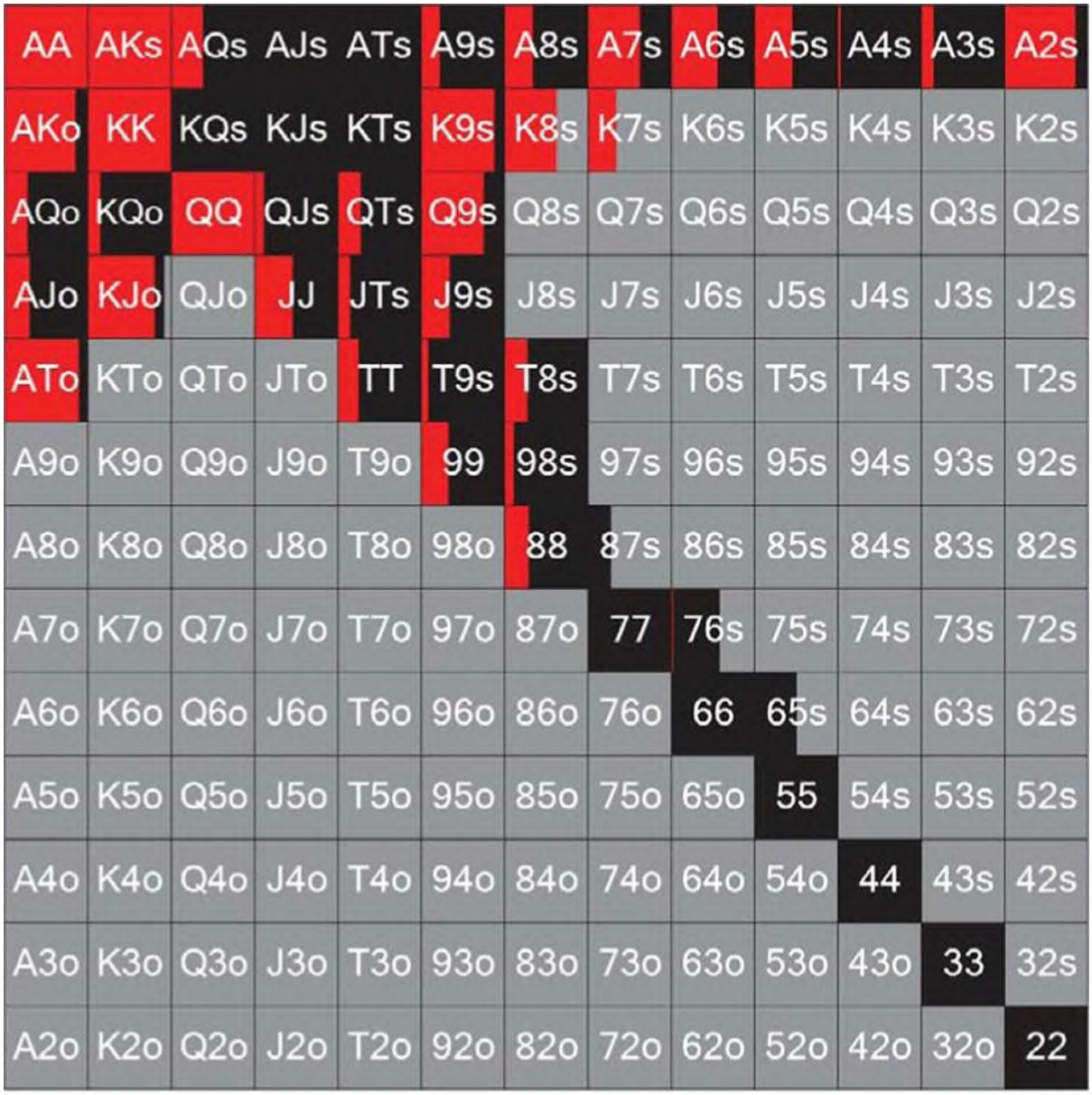
Defending the CO (60bb)

CO vs	3-bet	Call	Fold
HJ	9.10%	10.10%	80.80%
LJ	7.50%	11.70%	80.80%
UTG+2	6.40%	11.40%	82.20%
UTG+1	5.10%	12.80%	82.10%
UTG	5.20%	13.00%	81.80%
Average	6.66%	11.80%	81.54%

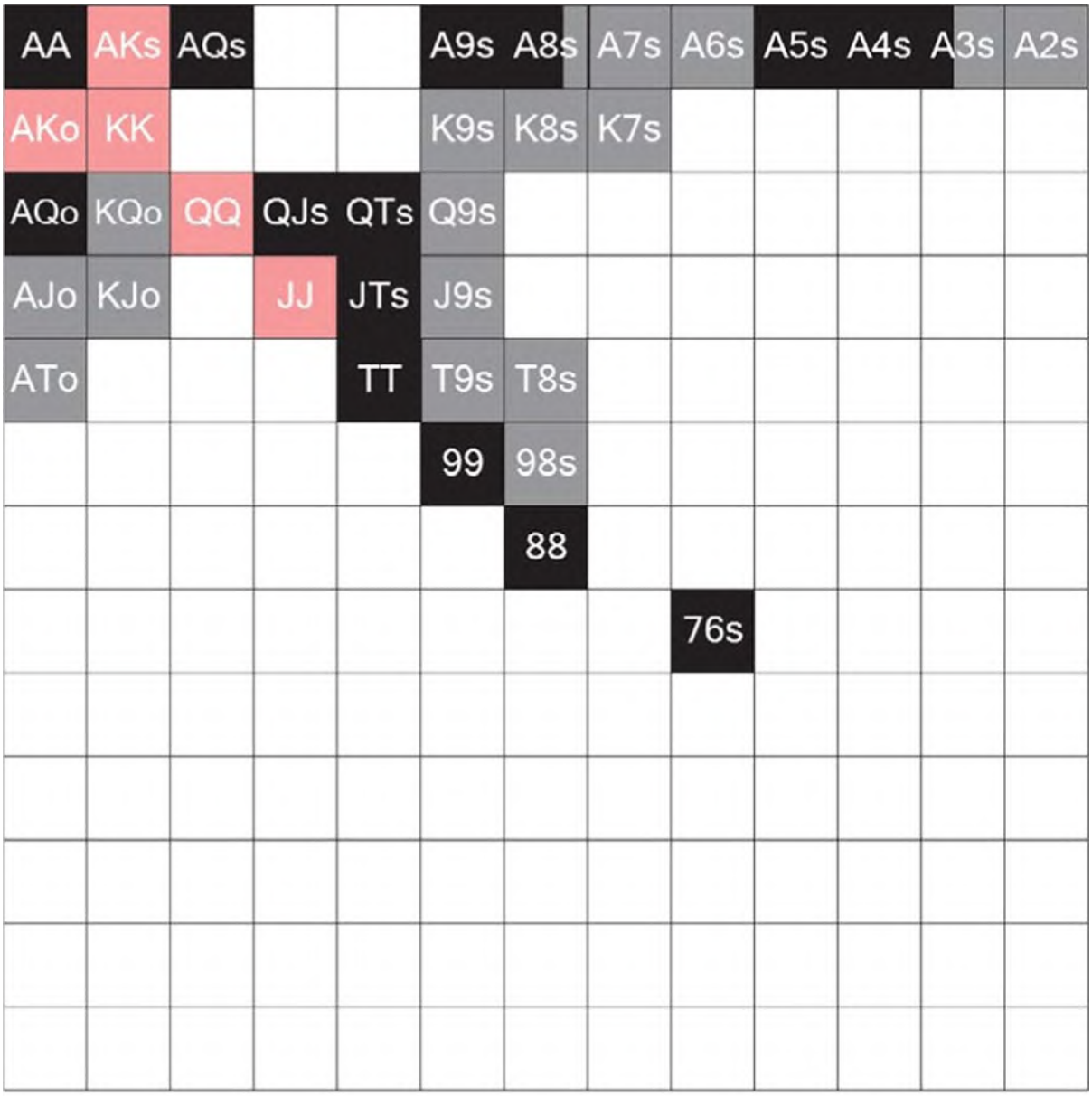
Table 74: CO Action Frequencies (60bb)

The CO 3-betting range is focused towards blocker hands, with a small frequency of suited and offsuit Ax and Kx, opting to flat call with suited broadways, suited Ax, suited connectors, pocket pairs and AKo-AJo.

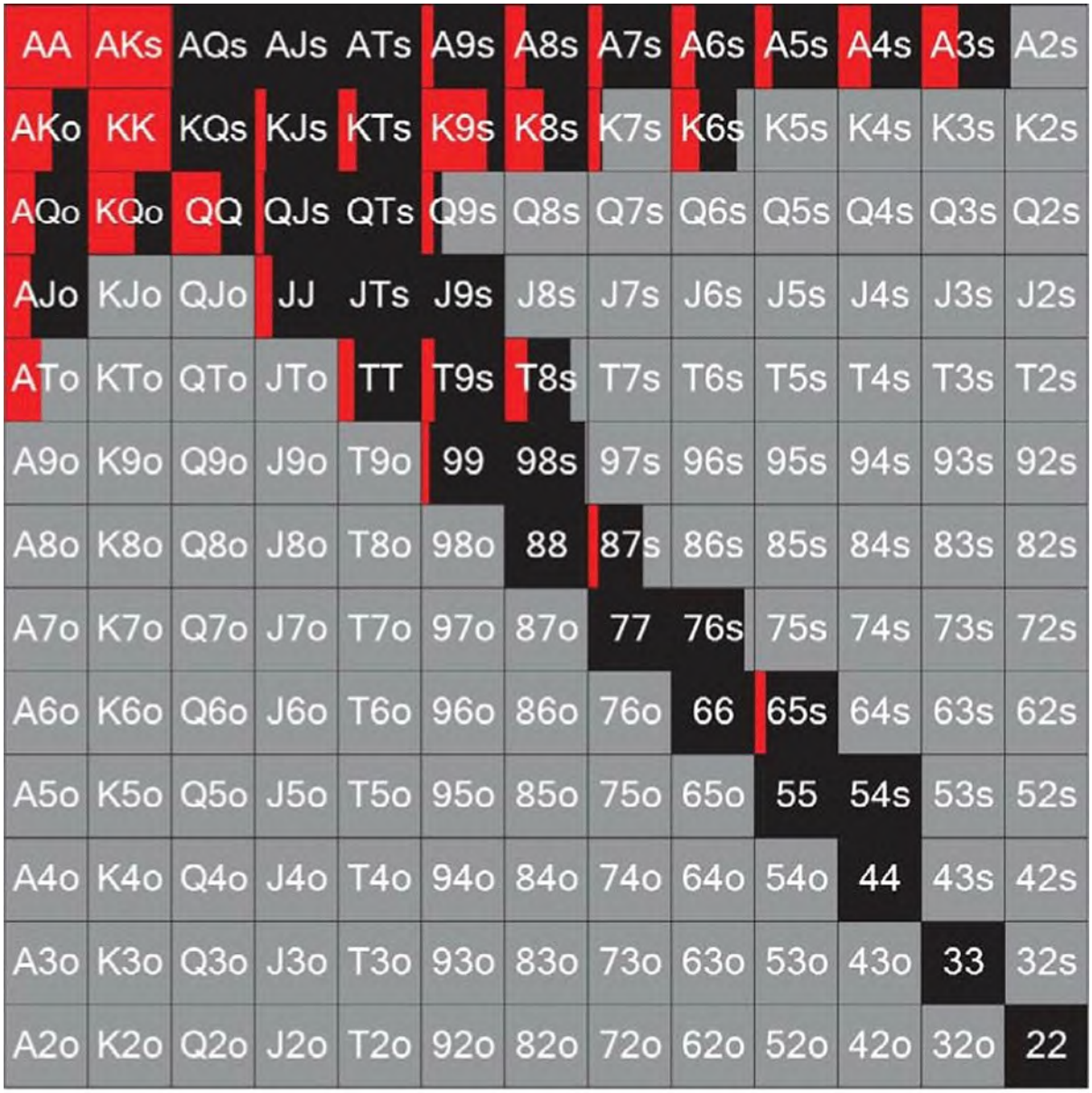
When facing an UTG 4-bet, the CO tends to get most of their continuing range all-in pre-flop (39%), with a small calling range of 7.7%. When facing a HJ 4-bet, the CO's calling range increases to 22% and the all-in range decreases to 29%, choosing to slow play AA. One of the main reasons for this is that the CO's 3-betting range vs UTG is more polarized than the 3-betting range vs the LJ, and so most hands play better as a 5-bet than as a call *(Hand Ranges 242-245)*.



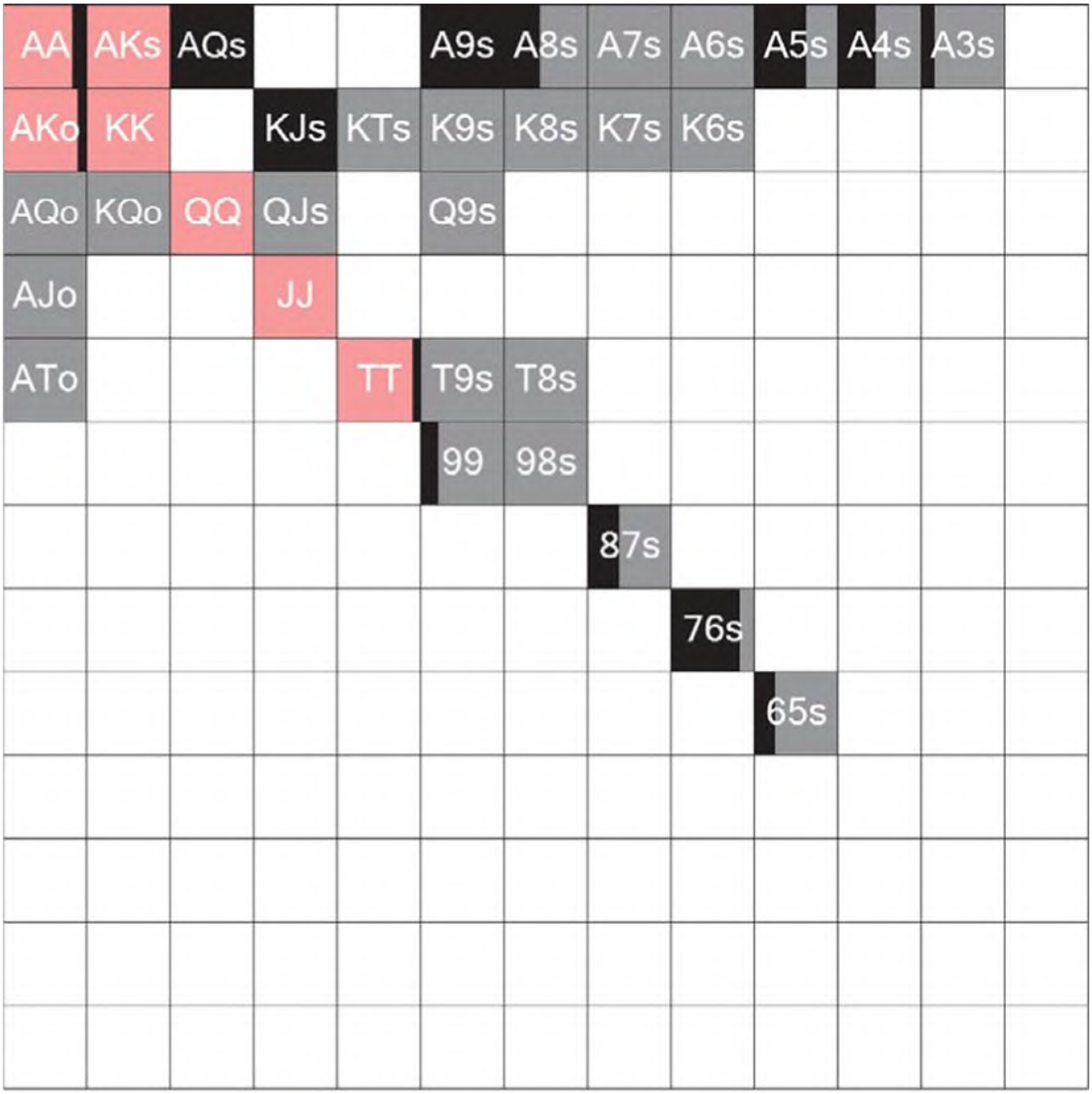
Hand Range 242: CO vs LJ (60bb) • 3-bet 7.5% / • Call 11.7% / • Fold 80.8%



Hand Range 243: CO vs LJ 4-bet (60bb) • All-in 29.3% / • Call 22.2% / • Fold 48.5%



Hand Range 244: CO vs UTG (60bb) • 3-bet 5.2% / • Call 13.0% / • Fold 81.8%



Hand Range 245: CO vs UTG 4-bet (60bb) • All-in 39.1% / • Call 7.7% / • Fold 53.2%

Defending the Hijack

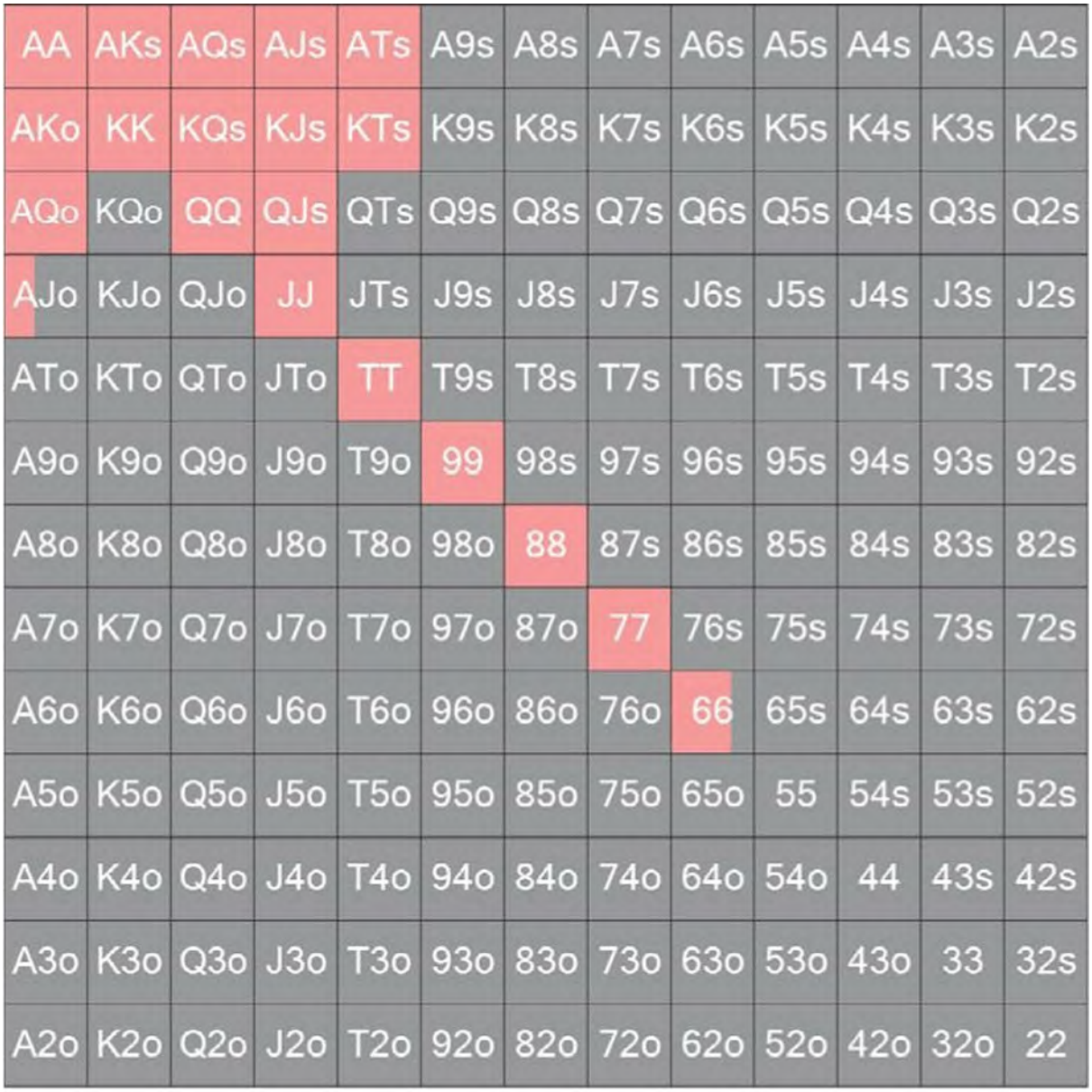
Defending the HJ (15bb)

Defending from the HJ vs open raises with 15bb involves rejamming a linear range with an average frequency of 9.3%, rejamming 8.5% vs UTG with 66+ AJo+, ATs+, KTs and QJs, adding A9s, KQo and JTs vs the HJ *(Hand Ranges 246-247)*.

HJ vs	All-in	Fold
LJ	10.40%	89.60%
UTG+2	9.60%	90.40%
UTG+1	8.70%	91.30%
UTG	8.50%	91.50%
Average	9.30%	90.70%

Table 75: HJ Action Frequencies (15bb)

Hand Range 246: HJ vs LJ (15bb) • All-in 10.4% / • Fold 89.6%



Hand Range 247: HJ vs UTG (15bb) • All-in 8.5% / • Fold 91.5%

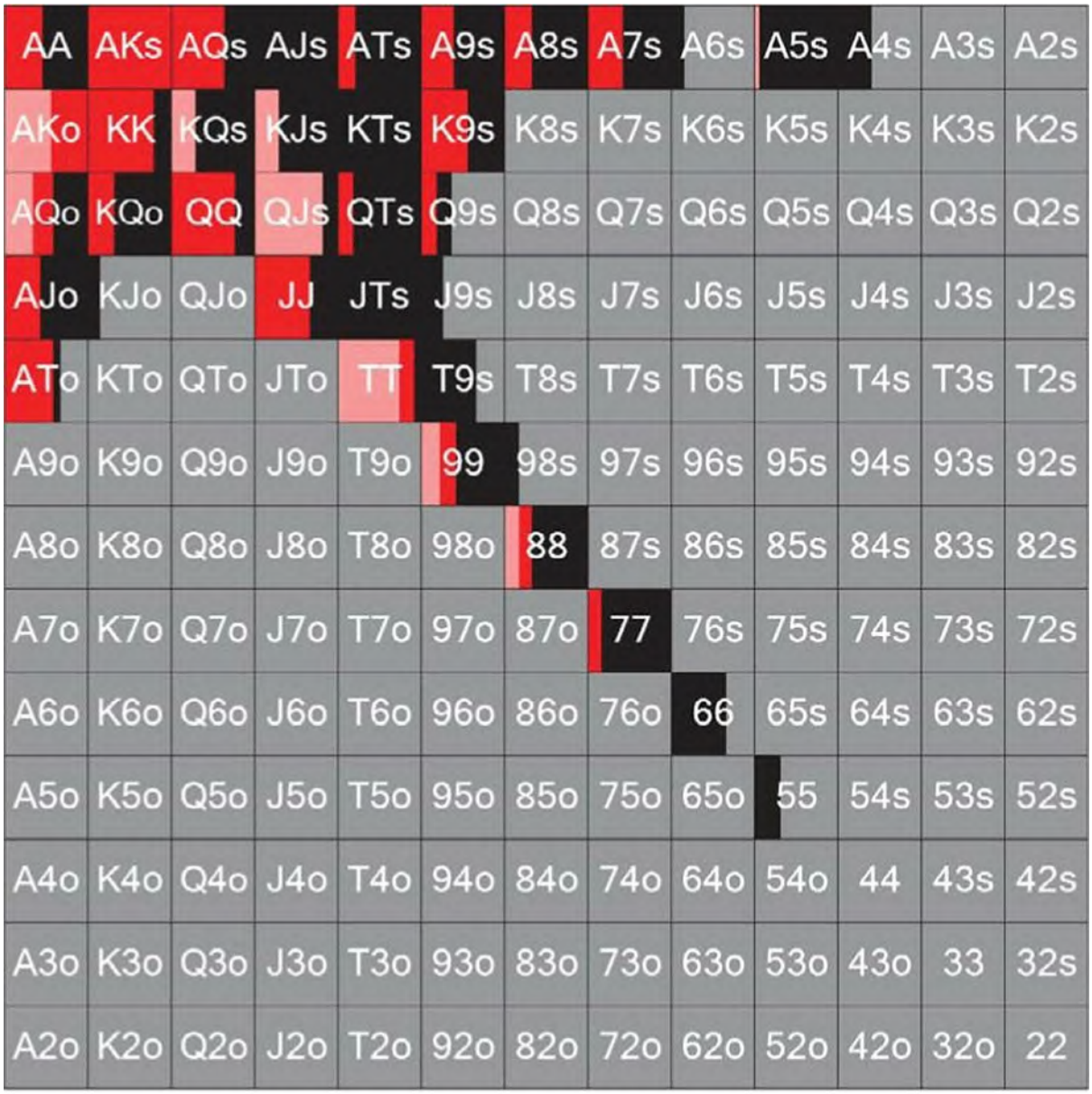
HJ vs	All-in	3-bet	Call	Fold
LJ	1.80%	4.50%	7.30%	86.40%
UTG+2	1.50%	4.80%	6.60%	87.00%
UTG+1	1.40%	4.50%	7.10%	87.00%
UTG	1.10%	3.90%	8.00%	87.00%
Average	1.45%	4.43%	7.25%	86.85%

Table 76: HJ Action Frequencies (25bb)

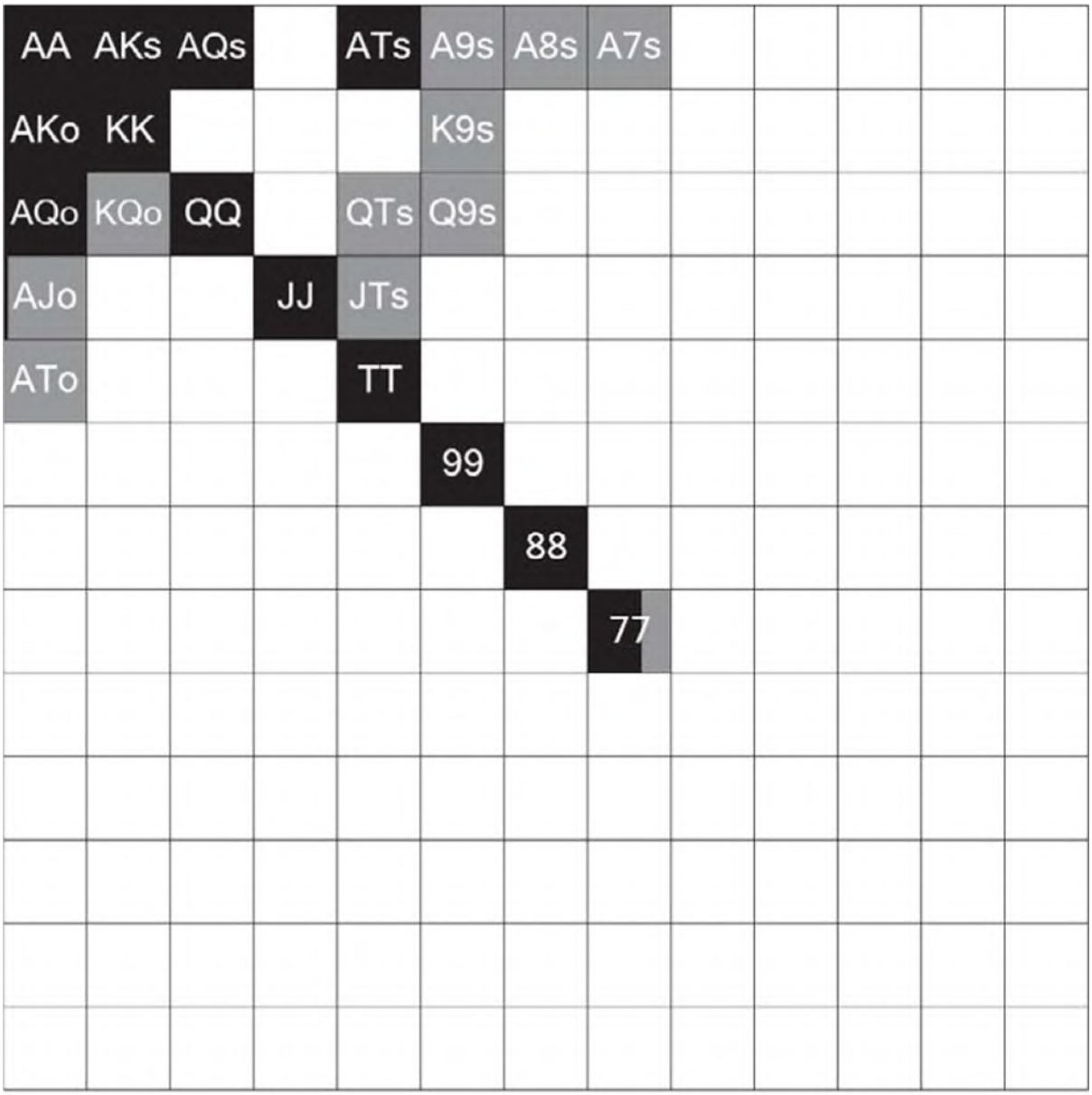
With 25bb, the GTO strategy rejams 1.45% on average. Again, this frequency is so low that, in practice, it is better to ignore the all-in range and instead play a 3-bet/call/fold strategy. If a hand is played with a mixed strategy between call/rejam, play it as a pure call, and if the mixed strategy involves a 3-bet non-all-in/rejam, play it as a pure non-all-in 3-bet.

The 4.43% on average 3-betting range is polarized, including the top of the range and a variety of bluffs such as ATs-A7s, AJo, ATo, KTs, K9s, and KQo. Notice this range is slightly stronger than it was from the later positions, CO and BN.

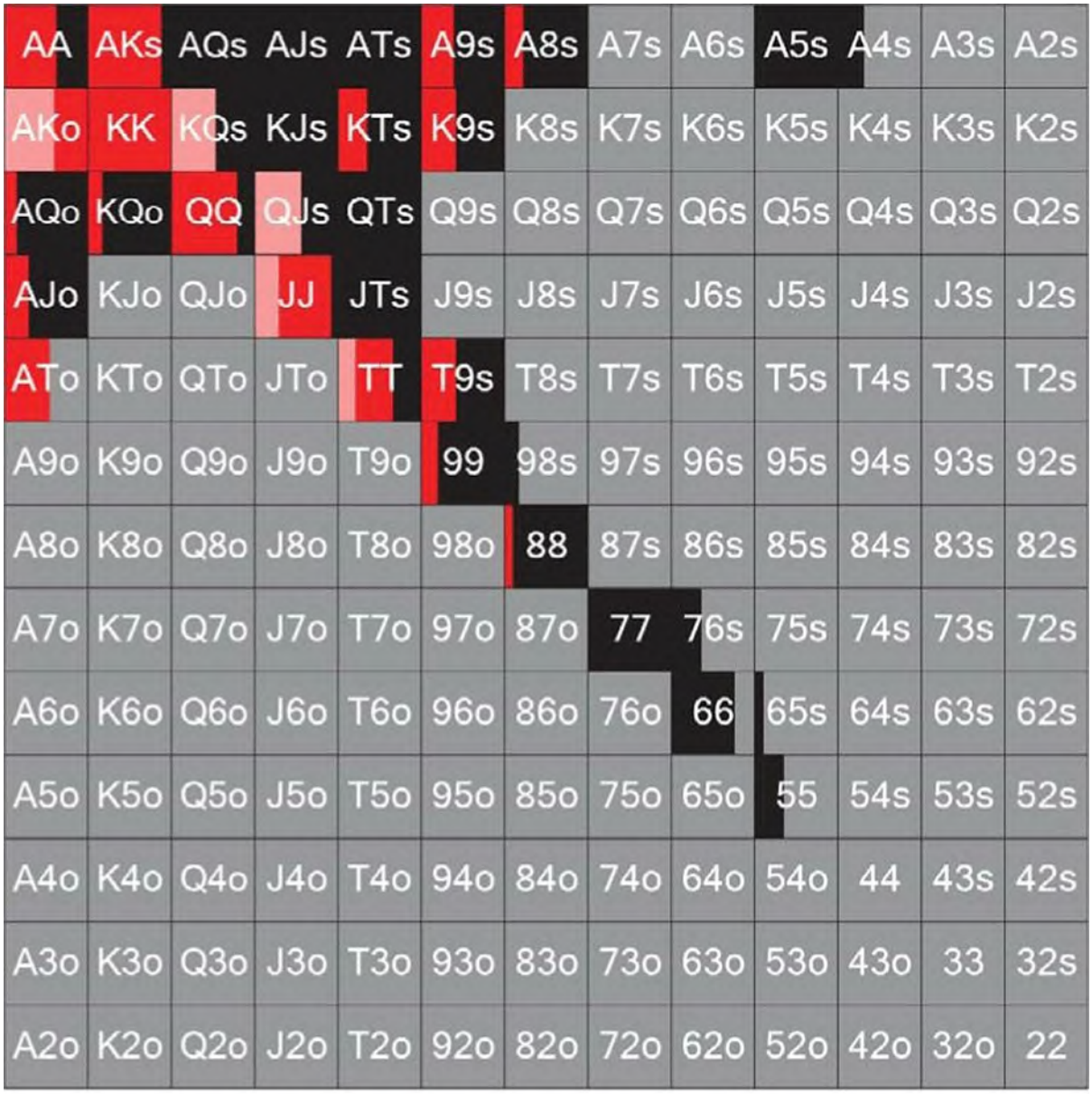
The calling range averages 7.25% and includes hands such as mid pocket pairs 99-55, AQo, AJo, KQo, suited broadways and some suited Ax including AQs-A8s, A7s, A5s and A4s *(Hand Ranges 248-251)*.



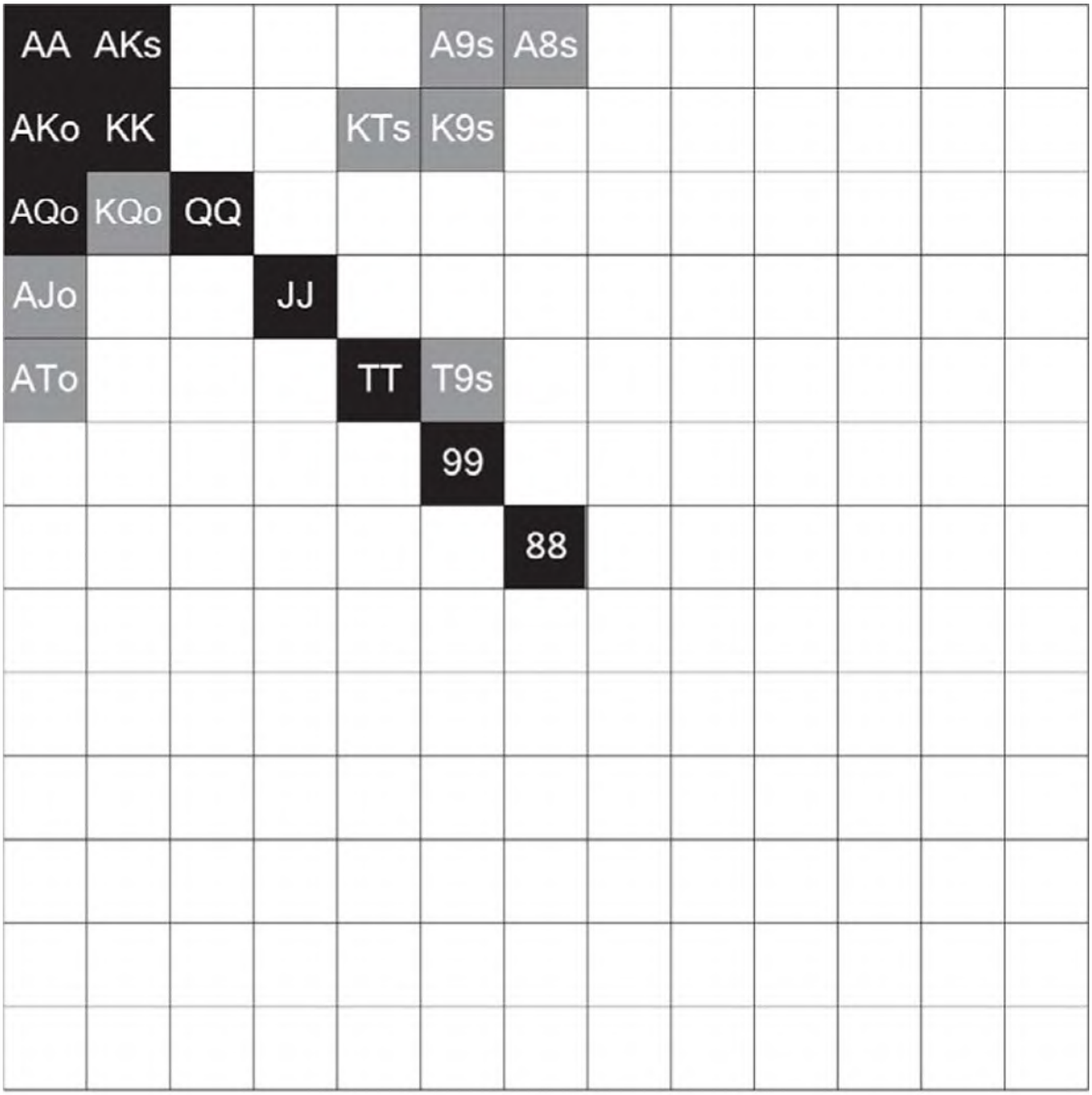
Hand Range 248: HJ vs LJ (25bb) • All-in 1.8% / • 3-bet 4.5% / • Call 7.3% / • Fold 86.4%



Hand Range 249: HJ vs LJ 4-bet (25bb) • Call 59.4% / • Fold 40.6%



Hand Range 250: HJ vs UTG (25bb) • All-in 1.1% / • 3-bet 3.9% / • Call 8% / • Fold 87%



Hand Range 251: HJ vs UTG 4-bet (25bb) • Call 62.9% / • Fold 37.1%

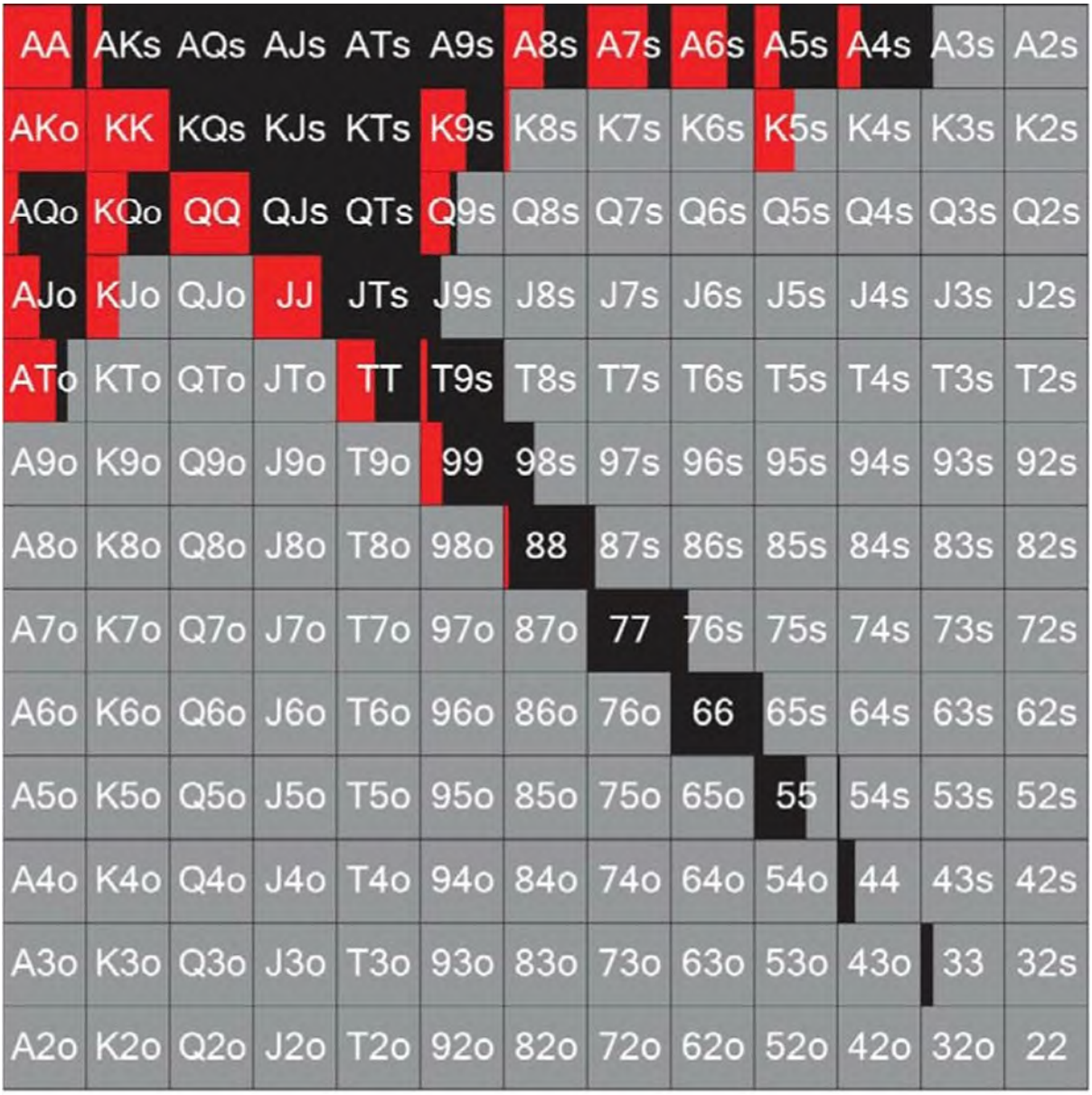
Defending the HJ (40bb)

HJ vs	3-bet	Call	Fold
LJ	6.10%	9.20%	84.70%
UTG+2	5.80%	9.00%	85.20%
UTG+1	5.10%	9.20%	85.70%
UTG	4.90%	8.90%	86.30%
Average	5.48%	9.08%	85.48%

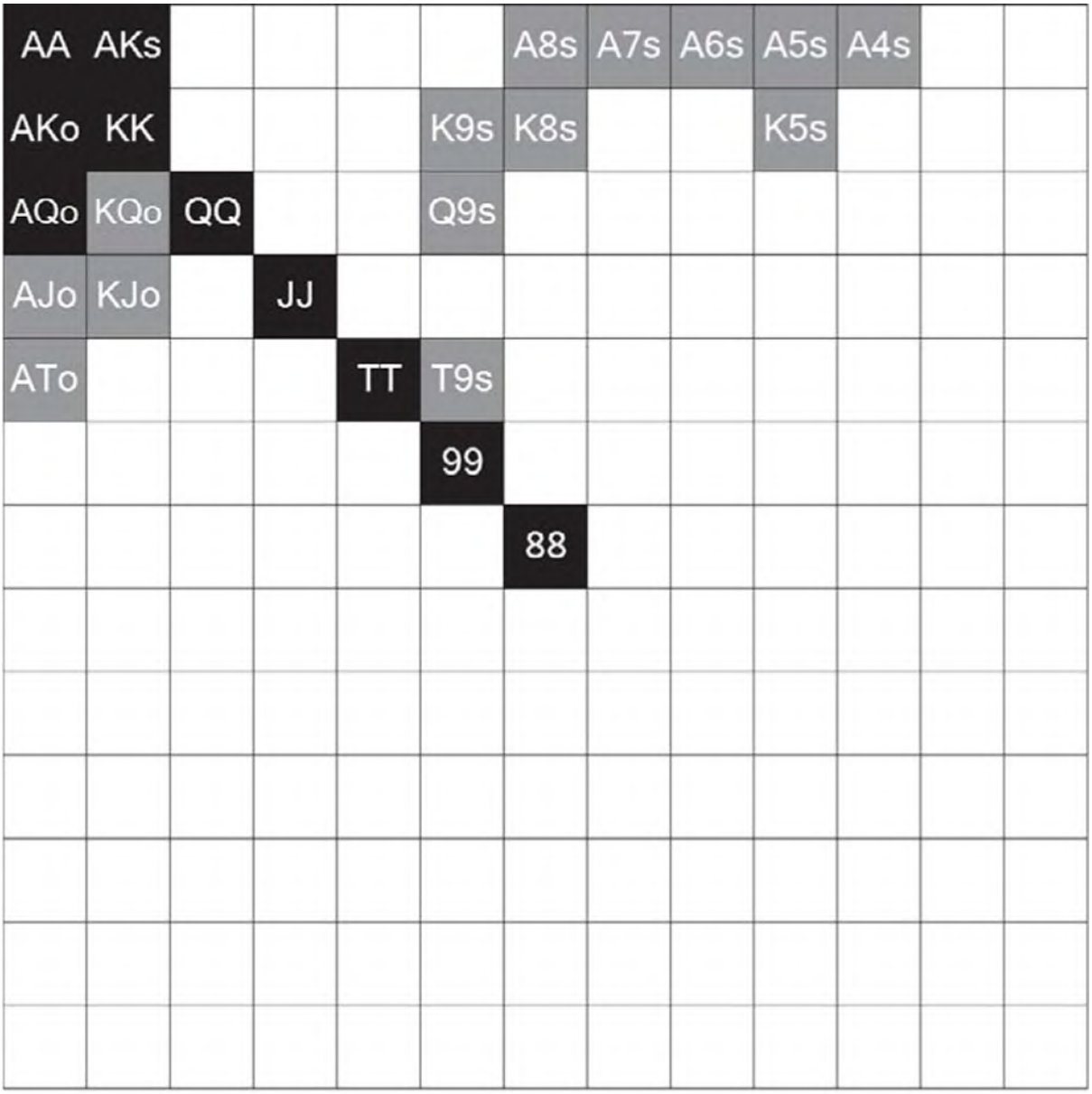
Table 77: HJ Action Frequencies (40bb)

With 40bb, the HJ 3-bets 5.48% on average with a polarized range. The 3-bet/folds are mid to low suited Ax, AJo, ATo, KQo, and some Kxs.

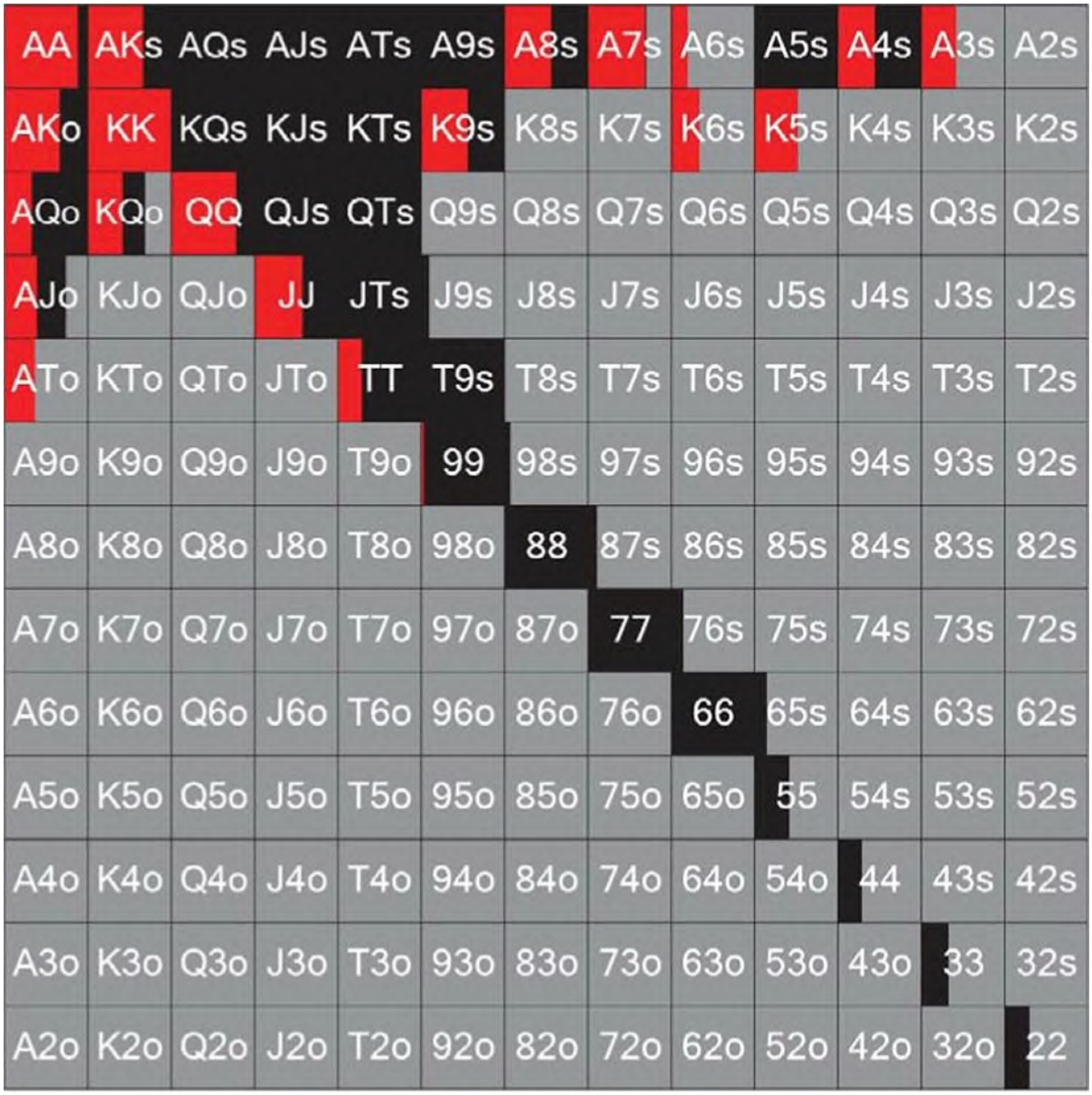
The calling range includes pocket pairs, AQo, AJo, KQo, suited broadways and suited connectors. The frequency with which the suited connectors are called increases as the initial raiser's range is wider *(Hand Ranges 252-255)*.



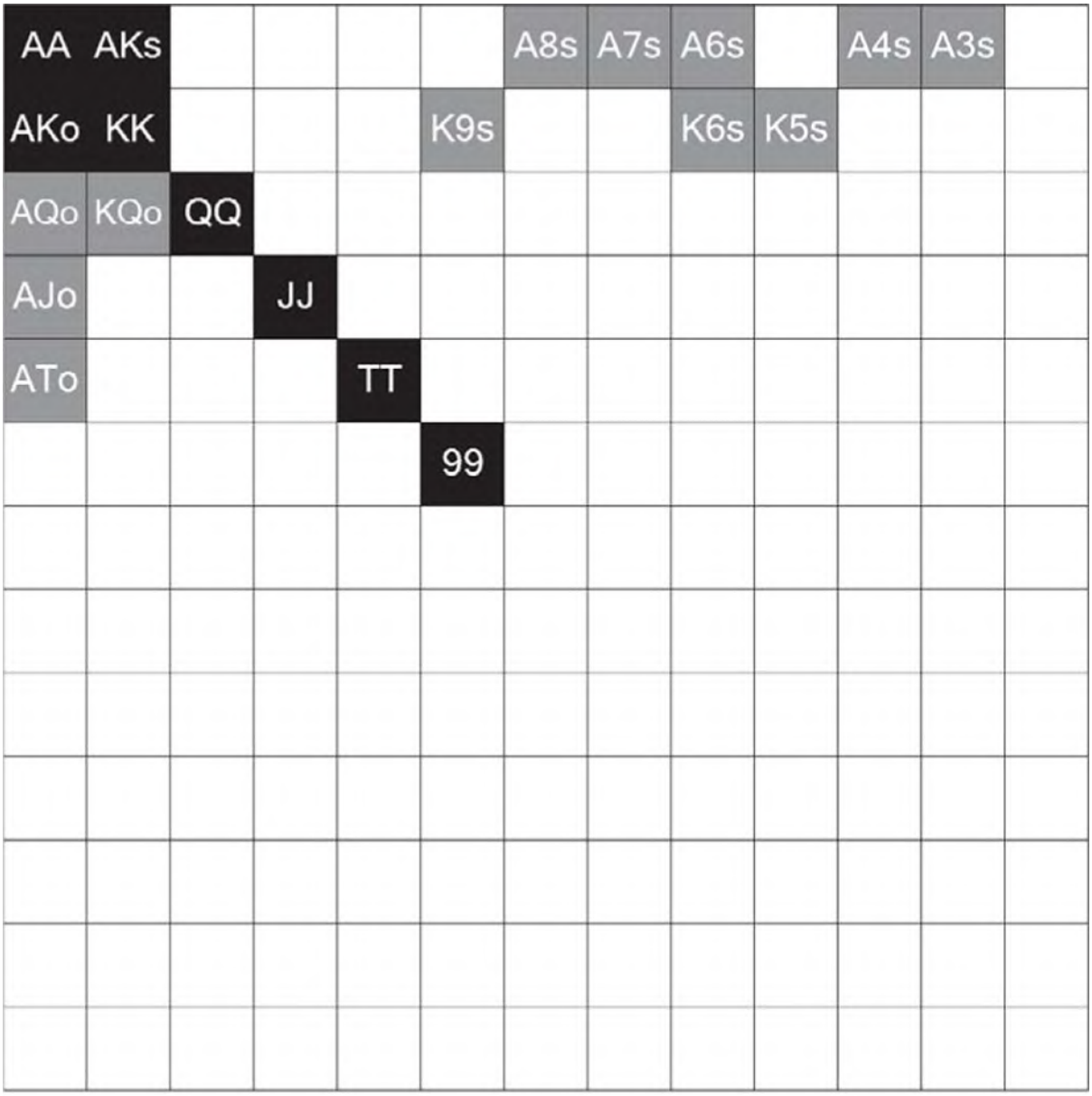
Hand Range 252: HJ vs LJ (40bb) • 3-bet 6.1% / • Call 9.2% / • Fold 84.7%



Hand Range 253: HJ vs LJ 4-bet (40bb) • Call 51% / • Fold 49%



Hand Range 254: HJ vs UTG (40bb) • 3-bet 4.9% / • Call 8.9% / • Fold 86.3%



Hand Range 255: HJ vs UTG 4-bet (40bb) • Call 49.2% / • Fold 50.8%

Defending the HJ (60bb)

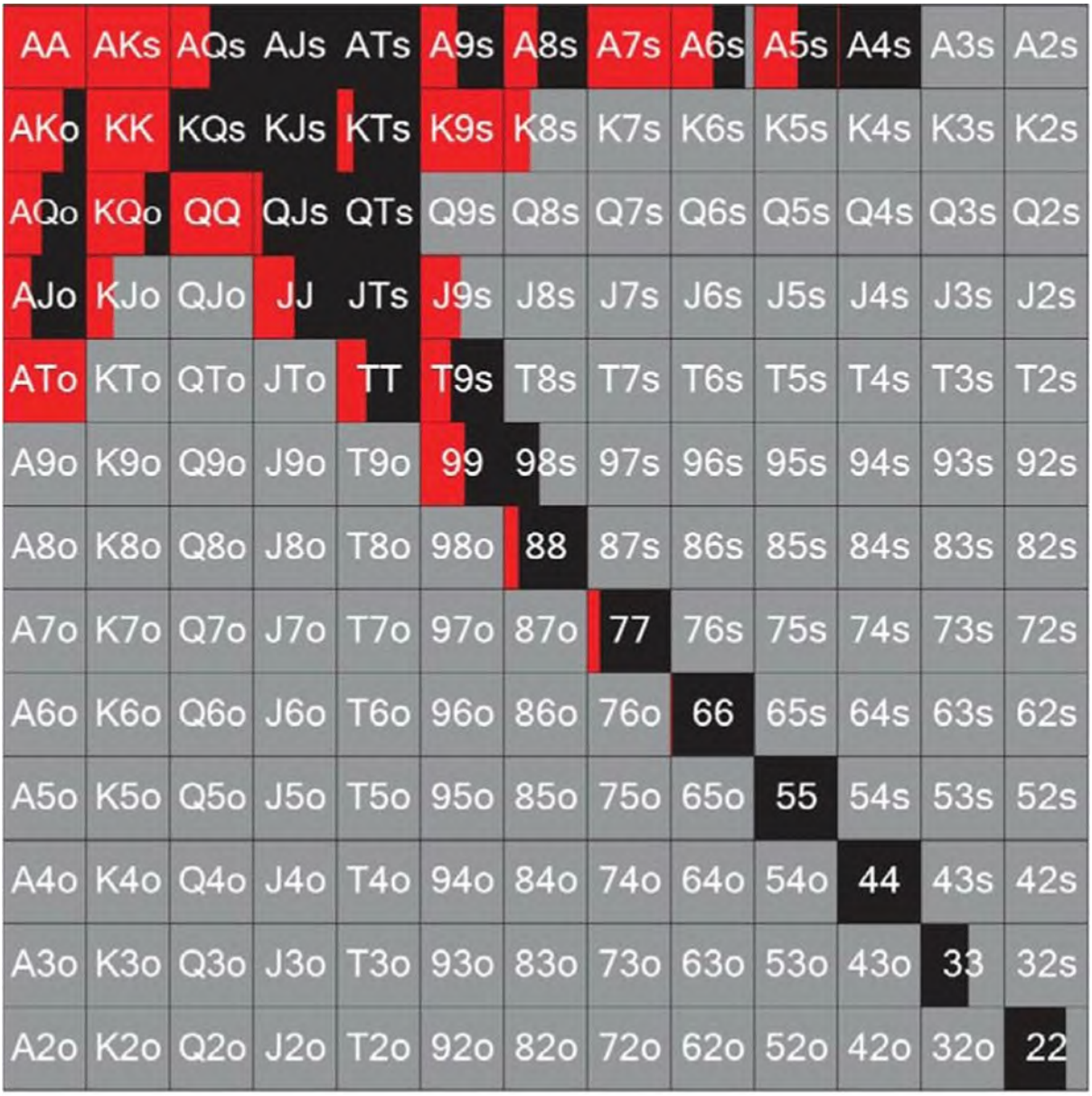
HJ vs	3-bet	Call	Fold
LJ	7.40%	8.80%	83.80%
UTG+2	6.10%	9.80%	84.10%
UTG+1	5.80%	9.30%	84.80%
UTG	5.20%	9.30%	85.50%
Average	6.13%	9.30%	84.55%

Table 78: HJ Action Frequencies (60bb)

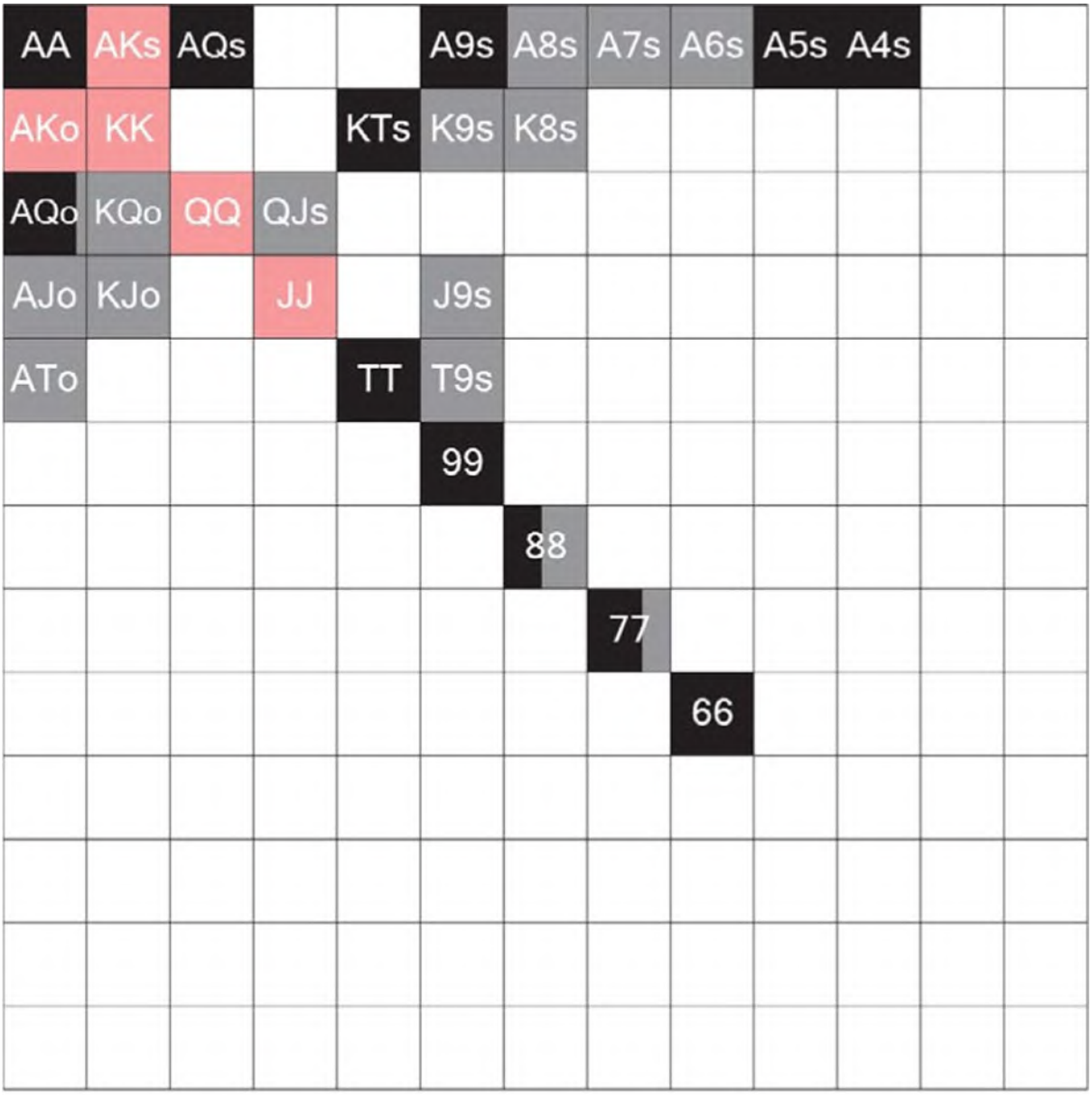
With 60bb the HJ 3-bets 6.13% on average, 3-betting the highest frequency vs the LJ (7.4%) and the lowest frequency vs UTG (5.20%). The 3-betting range is polarized but the 3-bet/fold range consists of high equity hands with good blockers and decent post-flop playability such as AQo- ATo, A9s- A5s, KQo, KJs-K8s.

The calling range includes pocket pairs, AQo-AJo, KQo, suited broadways, suited Ax and a small frequency of premium suited connectors.

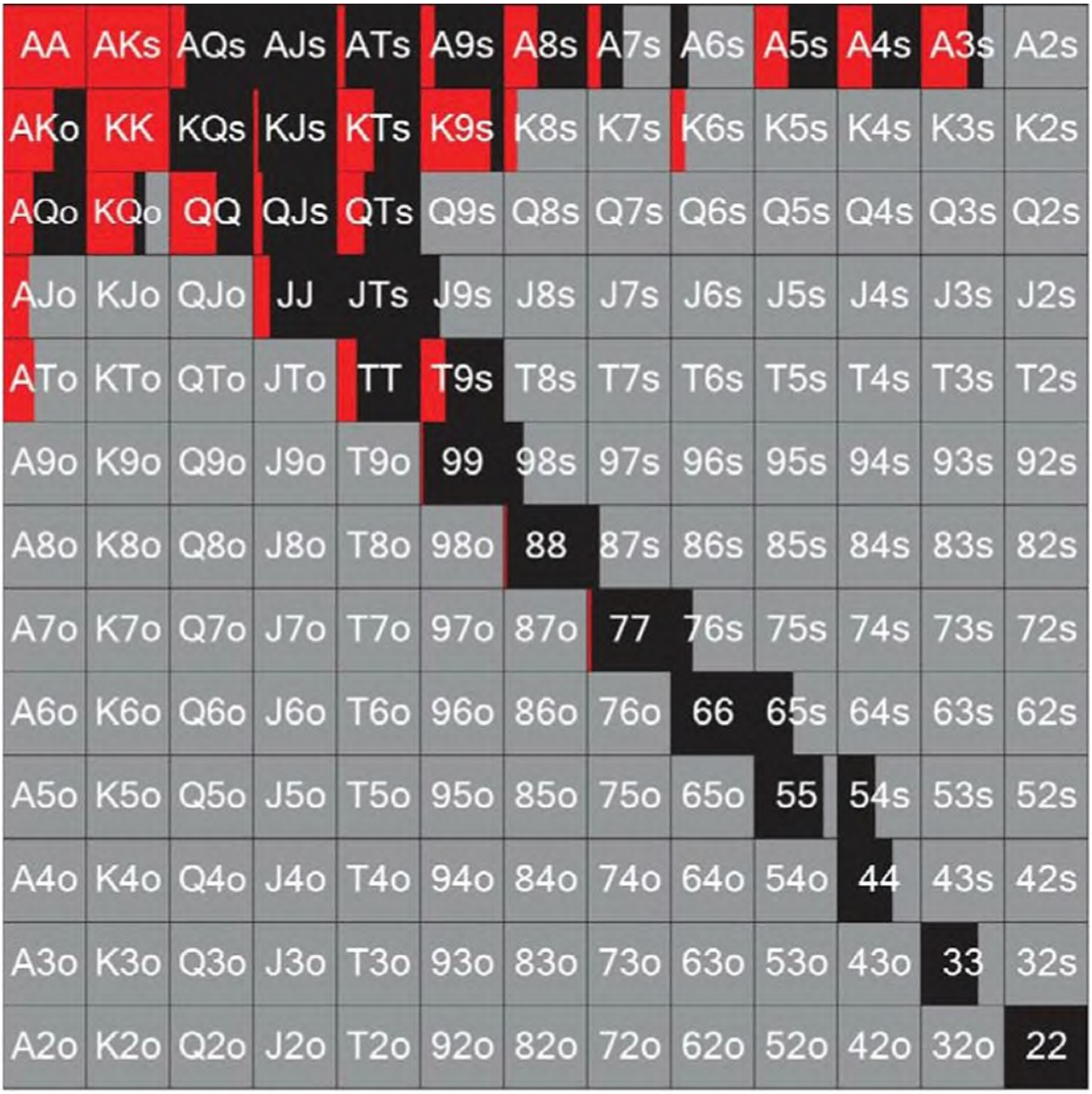
When facing a UTG 4-bet the HJ defends mostly by 5-betting all-in (39.2%), calling a small frequency (6.9%) and folding 53.9%. When facing a LJ 4-bet, the HJ strategy involves less 4-betting (28.2%) and more calling (24.5%) compared to the strategy played vs UTG 4-bets *(Hand Ranges 256-259)*.



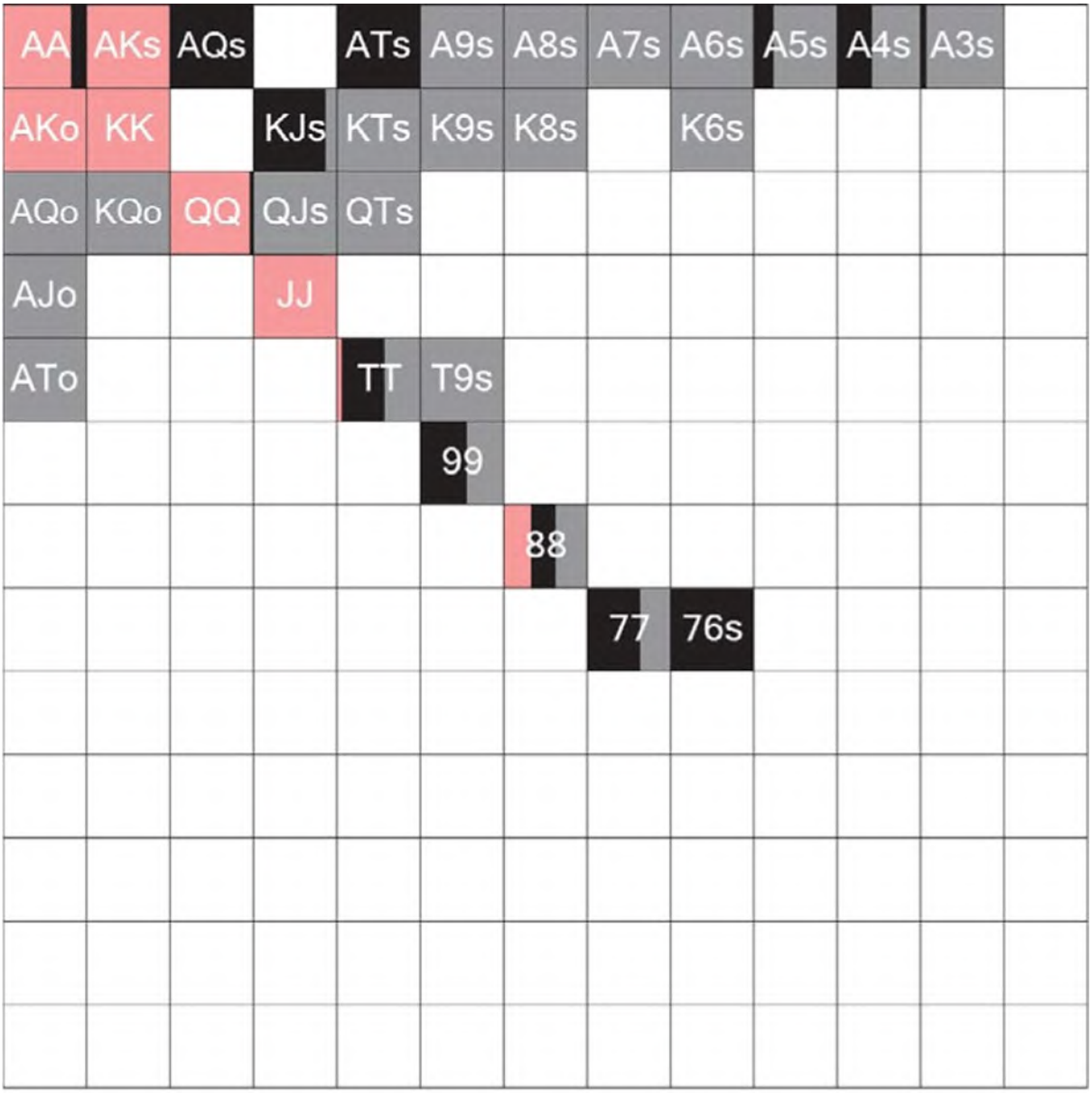
Hand Range 256: HJ vs LJ (60bb) • 3-bet 7.4% / • Call 8.8% / • Fold 83.8%



Hand Range 257: HJ vs LJ 4-bet (60bb) • All-in 28.2% / • Call 24.5% / • Fold 47.3%



Hand Range 258: HJ vs UTG (60bb) • 3-bet 5.2% / • Call 9.3% / • Fold 85.5%



Hand Range 259: HJ vs UTG 4-bet (60bb) • All-in 39.2% / • Call 6.9% / • Fold 53.9%

Defending UTG+1

UTG+1 vs	All-in	3-bet	Call	Fold
15	7.20%	0.00%	0.00%	92.80%
25	0.00%	5.10%	3.60%	91.20%
40	0.00%	4.80%	4.00%	91.20%
60	0.00%	5.70%	2.90%	91.40%
Average	1.80%	3.90%	2.63%	91.65%

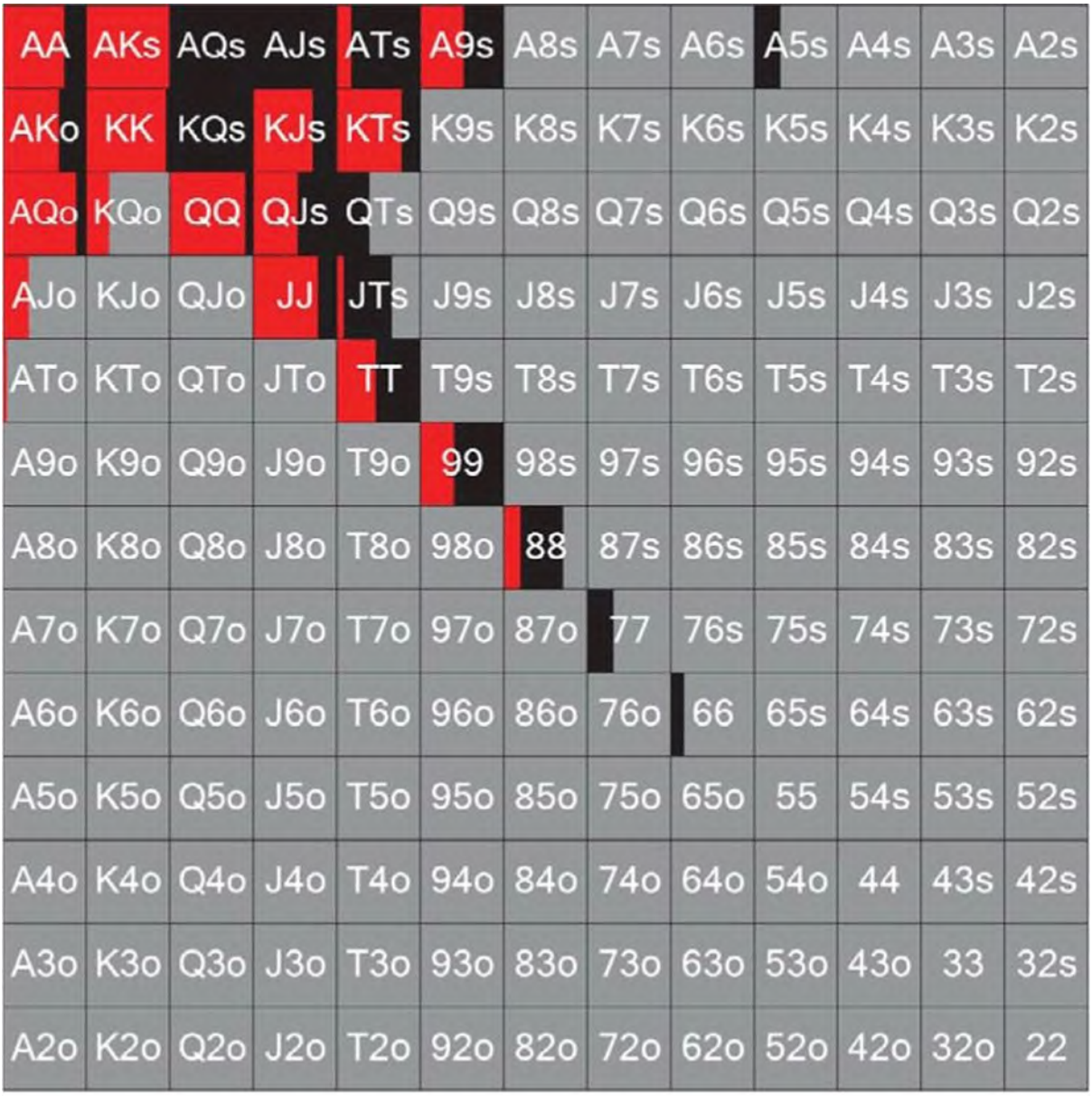
Table 79: UTG+1 Action Frequencies

With 15bb, UTG+1 vs UTG rejams a linear range of 7.1%. With 25bb there is no rejamming range, and UTG+1 incorporates a 3.6% flat-calling range that includes JJ-66, AQo+, and suited broadways. The 3-betting range of 5.1% is less polarized than it would be at 25bb from LP or MP as it uses slightly stronger hands as 3-bet/folds. With 40bb, the 3-betting range shrinks slightly to 4.80% and the shape of the range changes to include more suited Ax (A9s-A5s) and fewer suited broadways. Conversely, the flatting range increases slightly to 4% and incorporates more of the suited broadways than were 3-bet at 25bb.

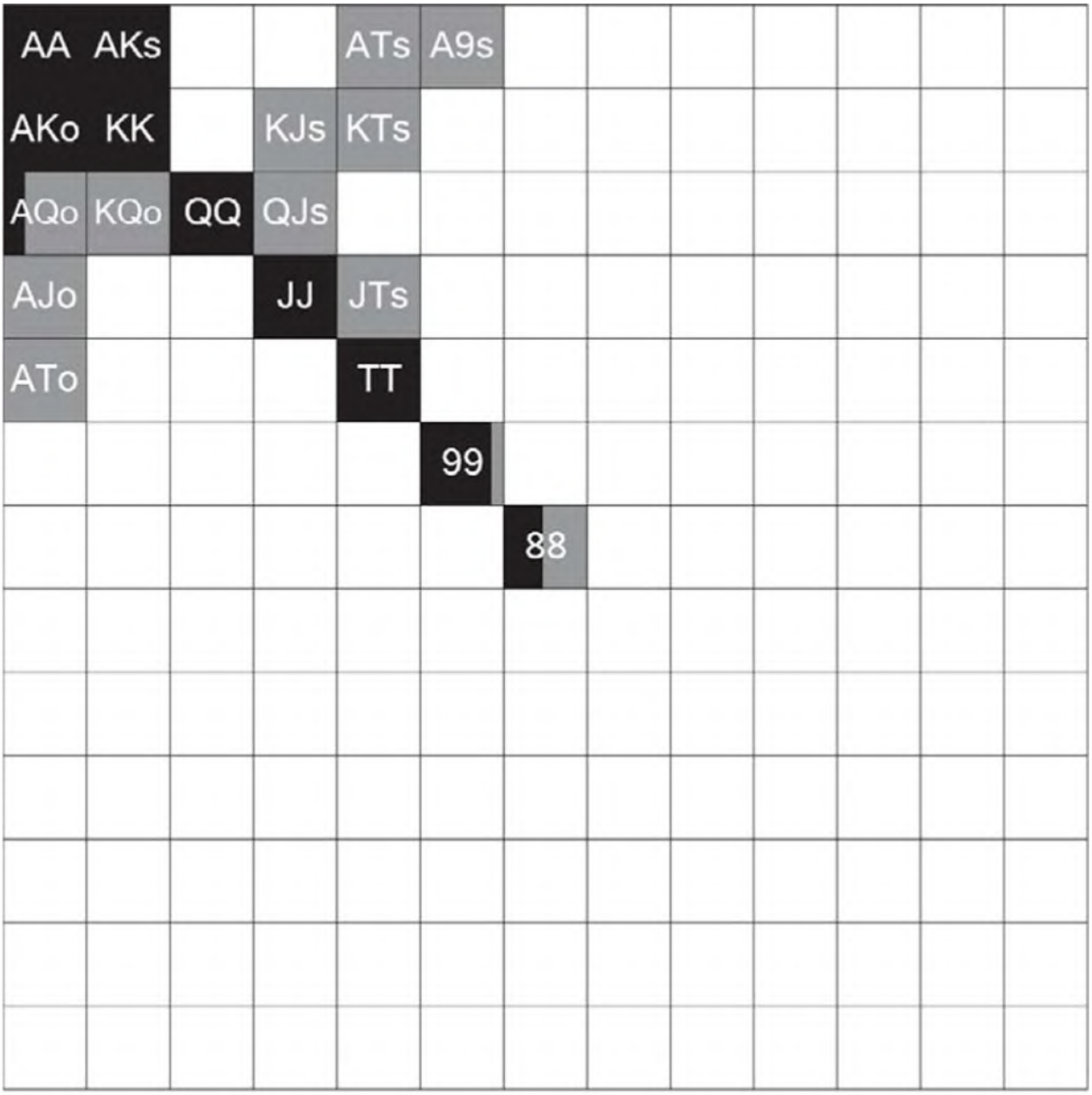
With 60bb, UTG 3-bets more often and calls less than it did with 40bb. The main reason is that, at 40bb, UTG's main response is to 4-bet all-in, which forces UTG+1 to fold many hands, denying equity. However, with 60bb, UTG will mostly defend vs the 3-bet by calling and playing OOP. For this reason, UTG+1 gets to realize a lot of equity post-flop and benefits by 3-betting a wider range *(Hand Ranges 260-266)*.

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

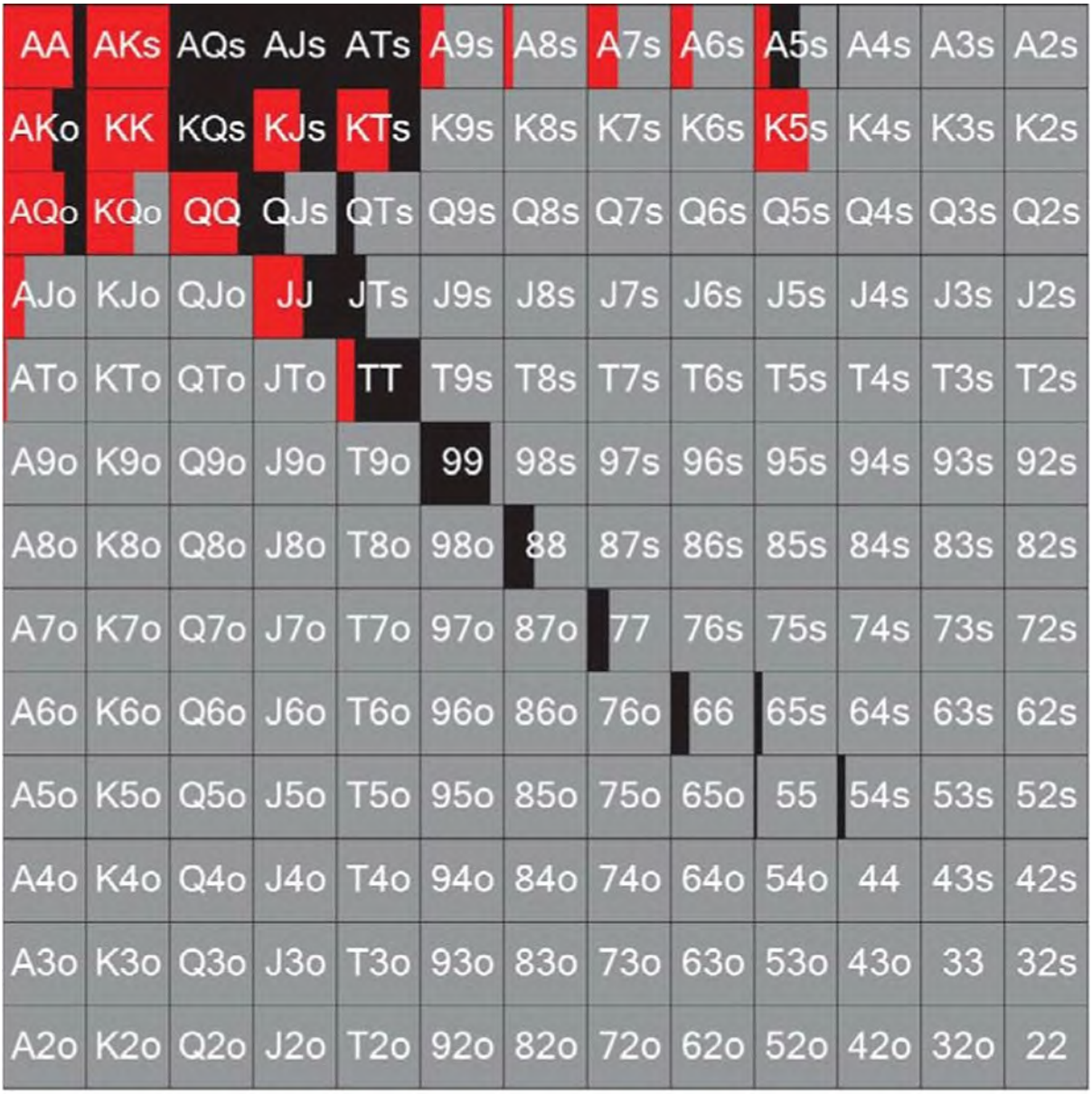
Hand Range 260: UTG+1 vs UTG (15bb) • All-in 7.1% / • Fold 92.8%



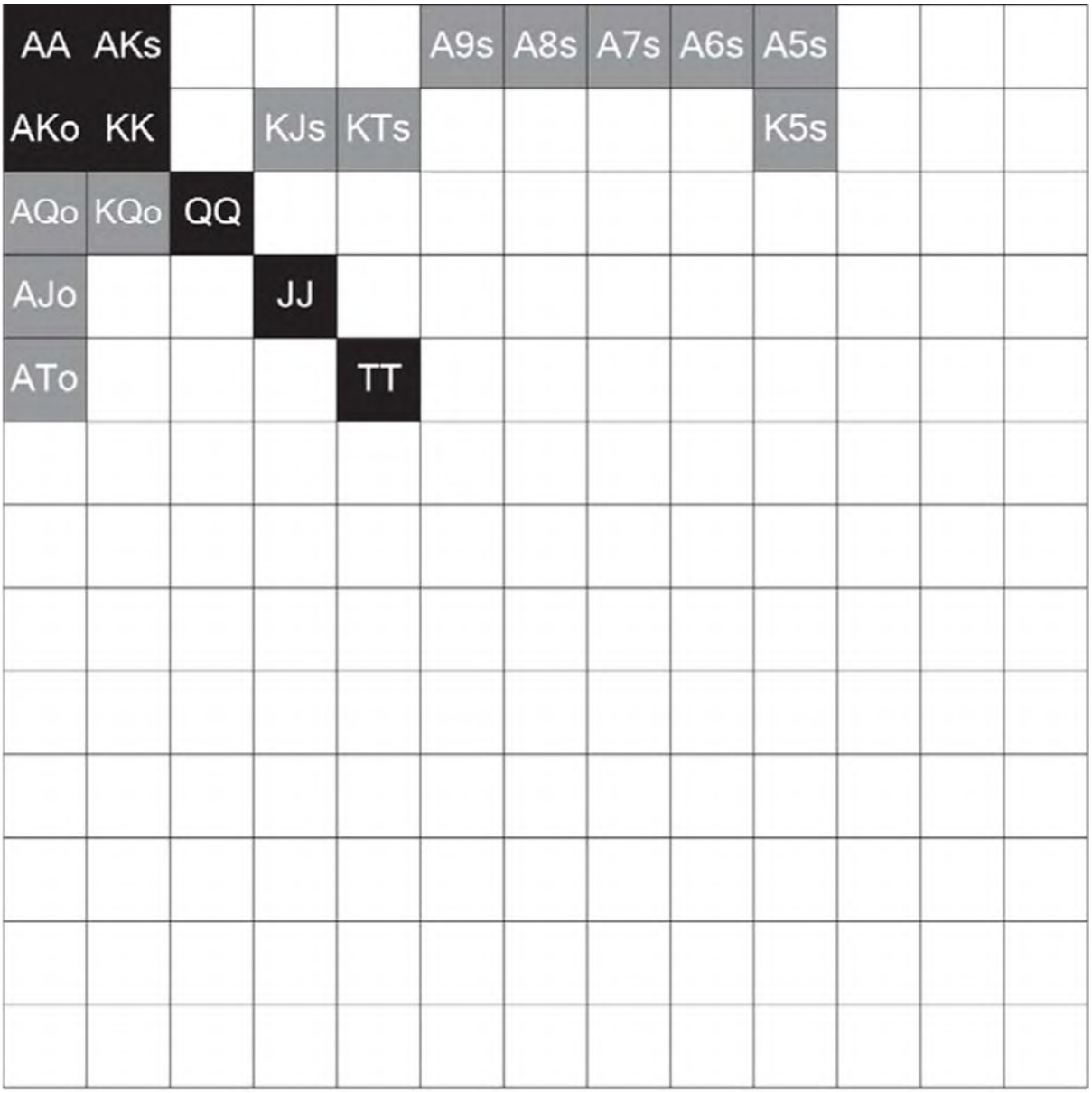
Hand Range 261: UTG+1 vs UTG (25bb) • 3-bet 5.1% / • Call 3.6% / • Fold 91.2%



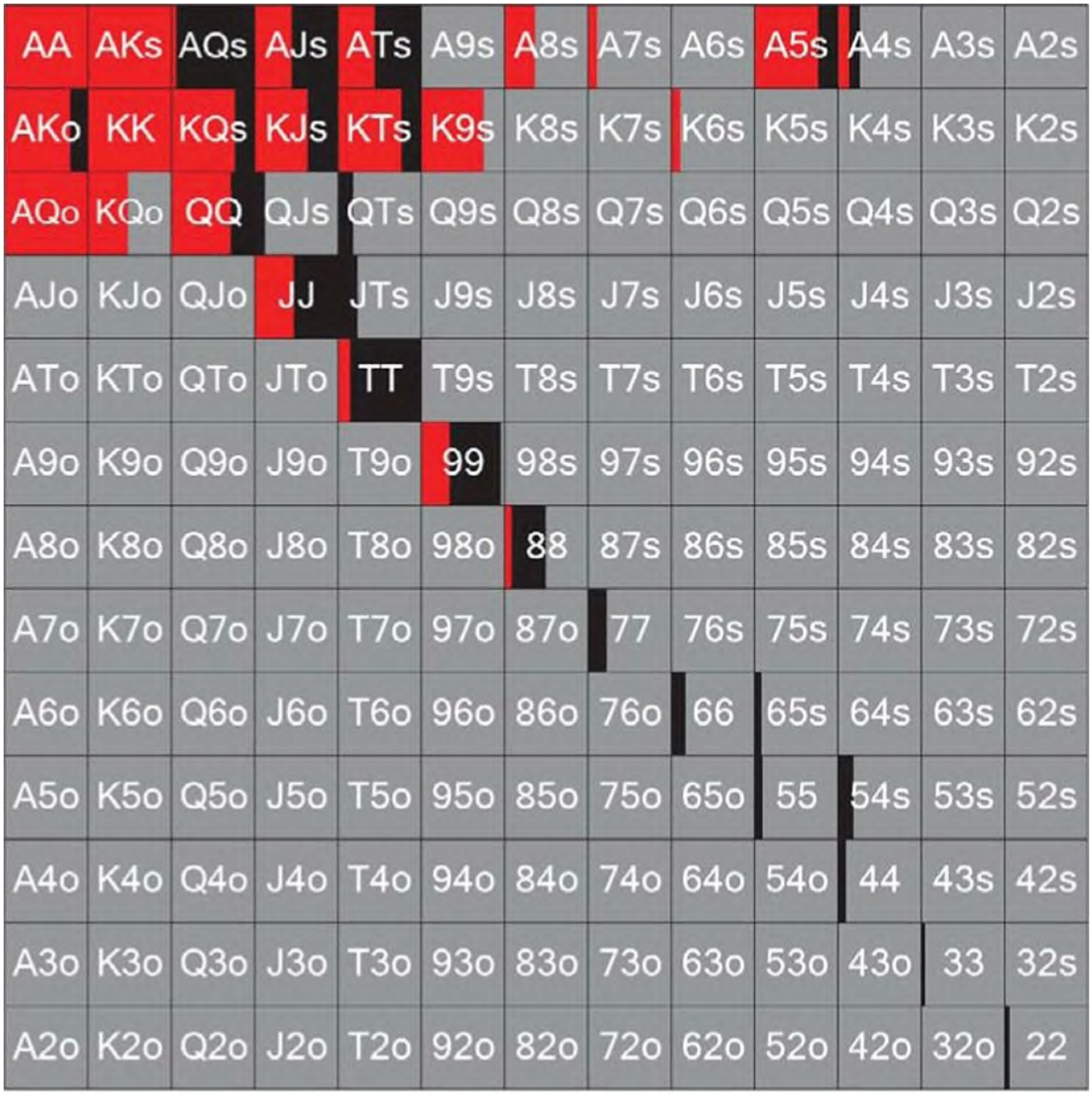
Hand Range 262: UTG+1 vs UTG 4-bet (25bb) • Call 59.7% / • Fold 40.3%



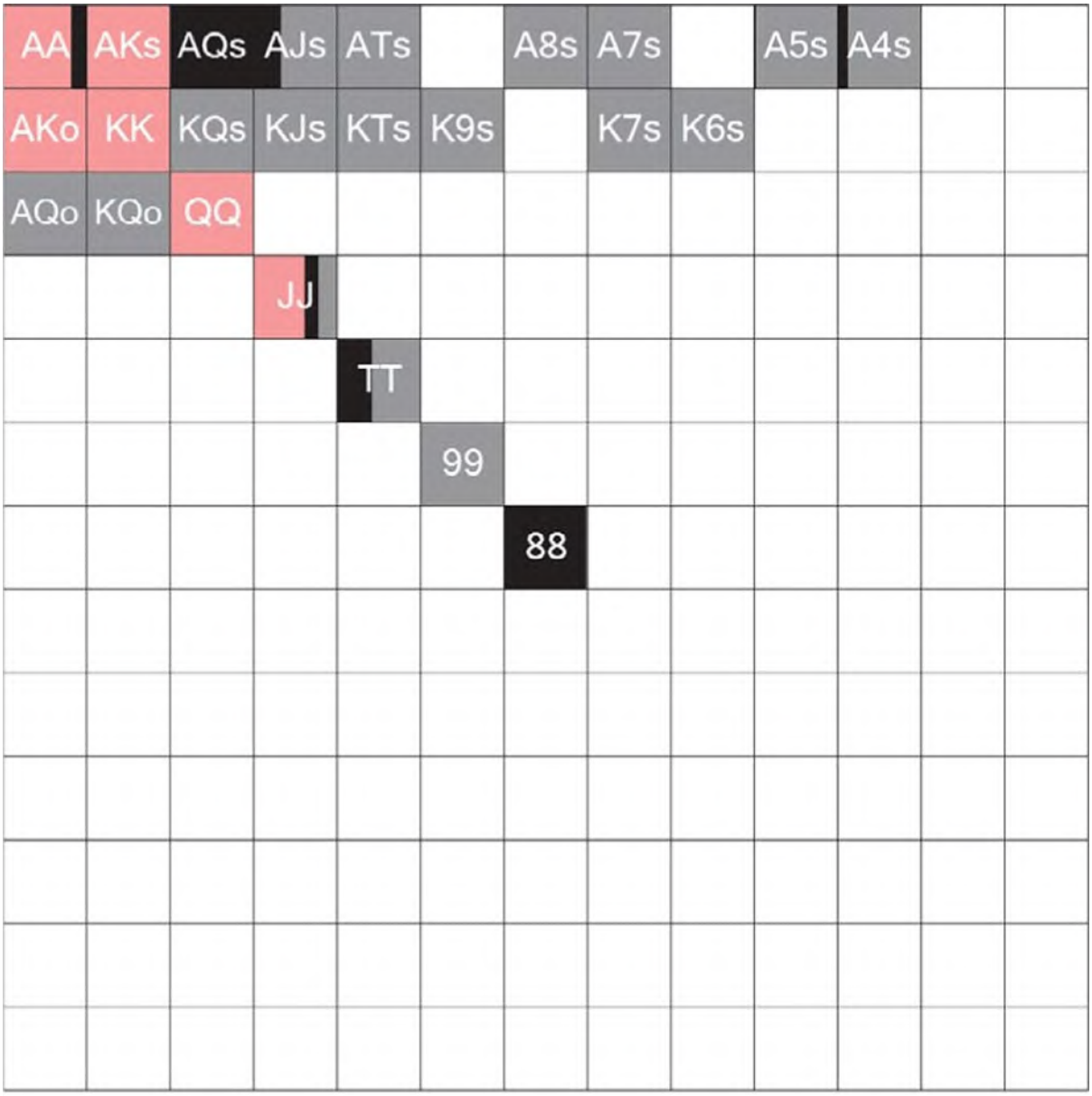
Hand Range 263: UTG+1 vs UTG (40bb) • 3-bet 4.8% / • Call 4% / • Fold 91.2%



Hand Range 264: UTG+1 vs UTG 4-bet (40bb) • Call 59.7% / • Fold 40.3%



Hand Range 265: UTG+1 vs UTG (60bb) • 3-bet 5.7% / • Call 2.9% / • Fold 91.4%



Hand Range 266: UTG+1 vs UTG 4-bet (60bb) • All-in 40.5% / • Call 4.4% / • Fold 55.1%

09

MTT EQUILIBRIUM

STRATEGIES: PLAYING VERSUS 3-BETS

The Key Factors

When facing a 3-bet after open-raising from any position, here are key factors that should influence your decision-making process:

- **Your position:** How strong is your opening range in this spot?
- **The Villain's position:** How strong is their 3-betting range?
- **Active players:** How many players have to act after the Villain 3-bets? The more active players remaining, the less likely it is that the Villain is bluffing and the fewer hands you need to defend to remain unexploitable.
- **The bet-size:** Is the 3-bet an all-in bet? Do you have the option to 4-bet with fold equity? Do you have the right odds to call with your hand given the 3-bet size and ranges in play?
- **Relative position:** If you call the 3-bet, will you have position post-flop? How difficult will it be to realize your equity post-flop?
- **Range morphology:** Is the 3-betting range polarized or linear? How well does your hand play post-flop vs the Villain's range?
- **Risk premium:** How deep are you in the tournament? Do you have a high or low risk premium vs the Villain? Do they have a high or low risk premium against you?
- **Future game situations:** If you call and lose, how does that impact your remaining stack? Do you lose the ability to raise/fold or do you put yourself in a marginal ICM situation due to the remaining stacks? Will you become the chip leader and earn the ability to push the medium stacks around if you win the hand?
- **Bluffing:** Is the Villain likely to be over-bluffing or under-bluffing in this specific spot?
- **The profitability of calling:** If calling is close to 0 cEV, chances are it will be slightly losing in terms of $EV.

This chapter examines how to defend vs 3-bets at equilibrium but, as mentioned throughout the book, the baseline ranges are meant to serve as only a guide. You should always be actively thinking about all the above variables when facing 3-bets in-game, and be able to adjust accordingly.

Since it is impossible to include the ranges for all possible permutations of positions and stack depths in a single book, I will present some of the most important and typical situations. Because the ranges change in a linear fashion, make a point to study the trends and fill in the gaps for any missing strategies by extrapolating from the ones present in the text. Again, instead of trying to memorize fixed strategies, it is important to understand the following concepts: how the ranges are built, what type of hands are best used for raising, calling or folding and the reason why the solver chooses each type of hand to perform certain actions.

> *By trying to understand why the solver chooses the decisions it makes, you will be able to make better decisions in-game, using theory to your advantage to maximize EV.*

Additionally, you should never worry about trying to execute the strategies perfectly. No human will be able to exploit you if you do some rounding or a few simplifications as long as the main ideas behind the strategies are applied correctly.

Short Stack 2x Open Versus Rejam (10-25bb)

The following tables demonstrate the action frequencies when facing a 3-bet in terms of your position *(Table 80)*, Villain's position *(Table 81)* and stack depth *(Table 82)*.

The Average Fold after you make a min-raise vs a rejam with short stacks (10-25bb) is 55.04% and the average call is 44.96%.

By Position	Average Call	Average Fold
BN	42.11%	57.89%
UTG	44.69%	55.31%
HJ	44.70%	55.30%
UTG+1	44.78%	55.22%
UTG+2	45.63%	54.37%
LJ	45.70%	54.30%
CO	45.73%	54.27%

Table 80: Action Frequencies by Position

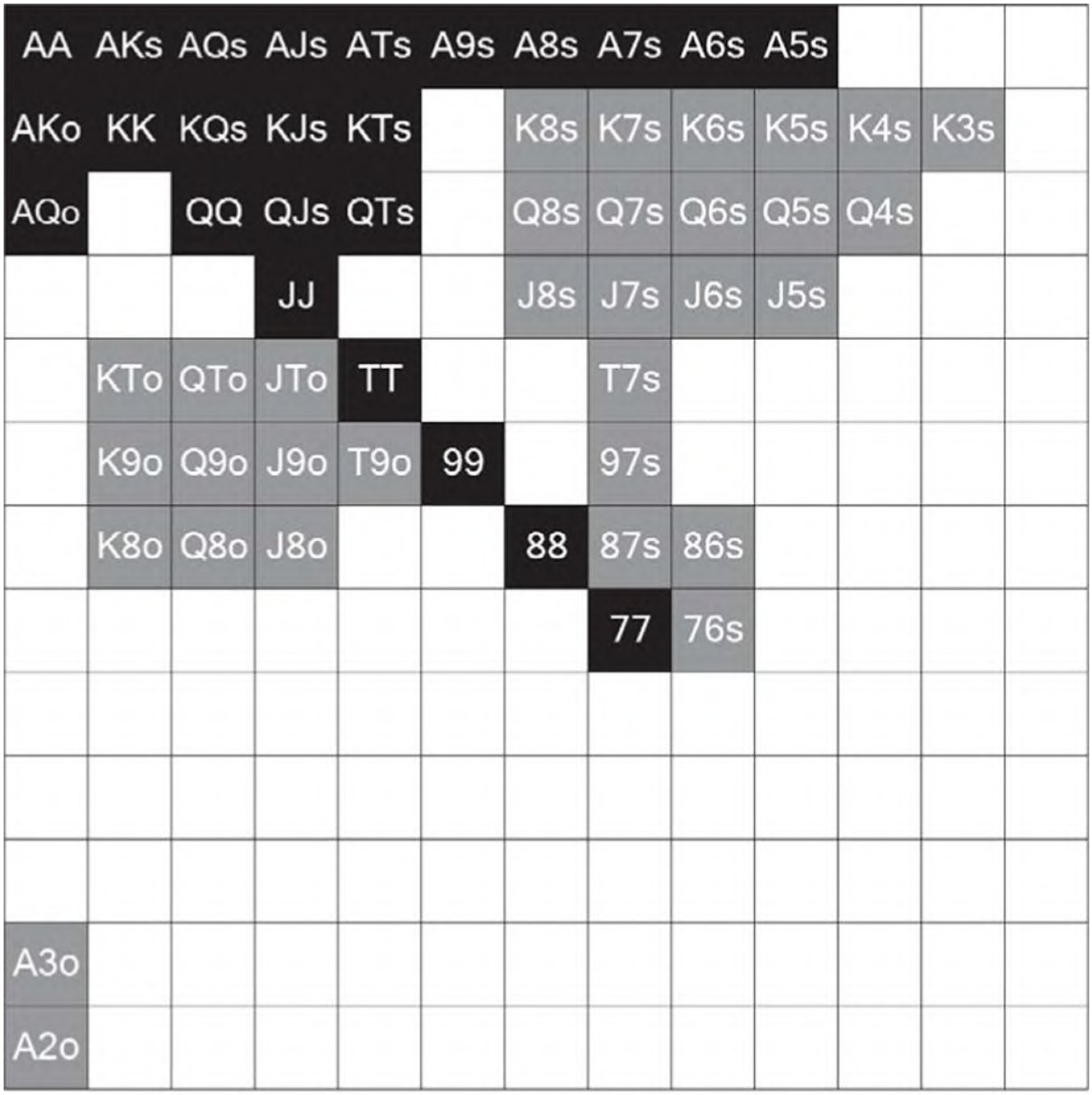
Versus Position	Average Call	Average Fold
UTG+1	39.32%	60.68%
UTG+2	40.71%	59.29%
LJ	41.65%	58.35%
HJ	42.72%	57.28%
CO	44.15%	55.85%
BN	45.37%	54.63%
BB	46.08%	53.92%
SB	48.78%	51.22%

Table 81: Action Frequencies Versus Position

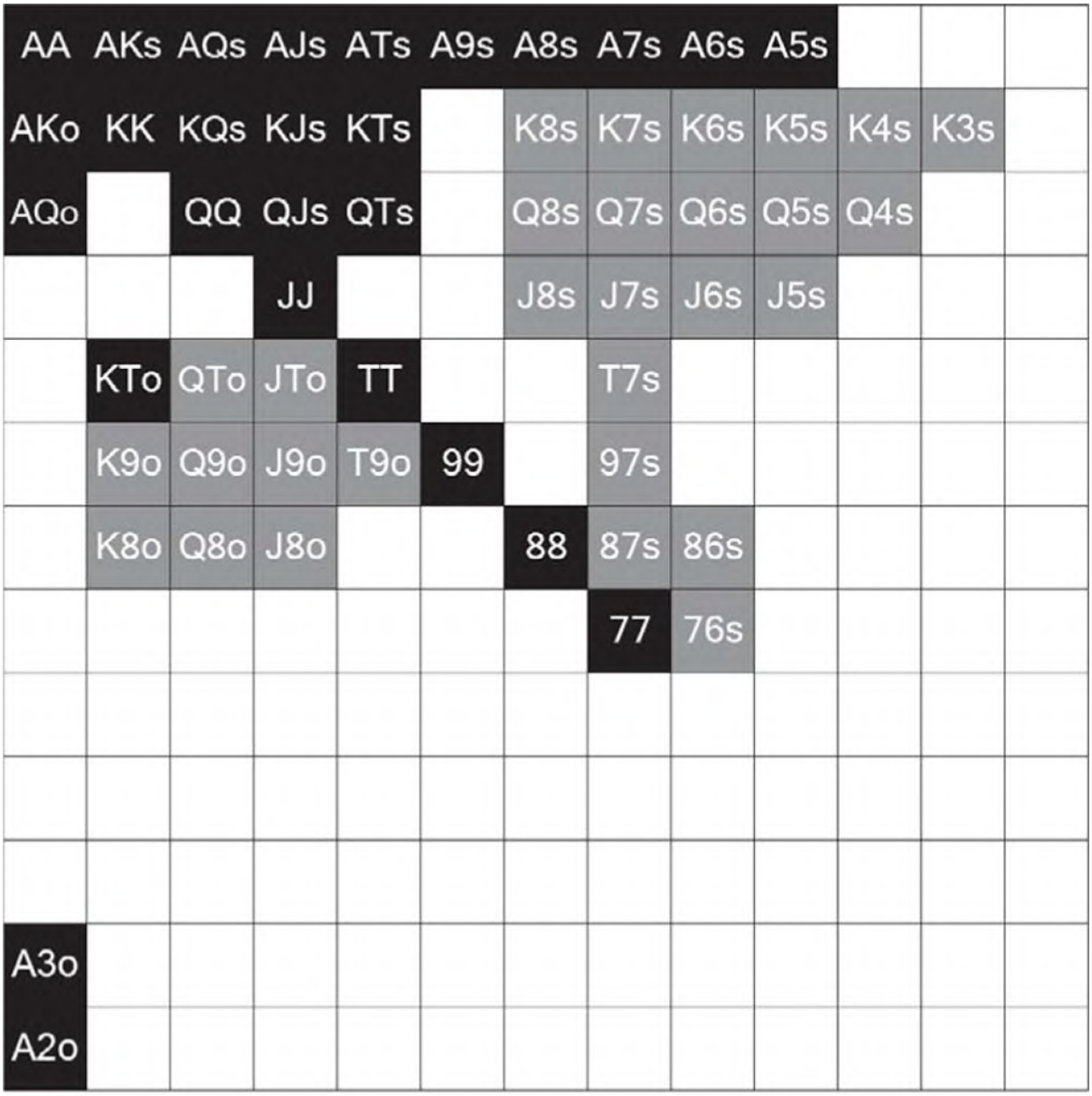
By Stack Depth	Average Call	Average Fold
25	30.57%	69.43%
20	37.79%	62.21%
17	43.91%	56.09%
15	47.75%	52.25%
12	52.03%	47.97%
10	57.69%	42.31%

Table 82: Action Frequencies by Stack Depth

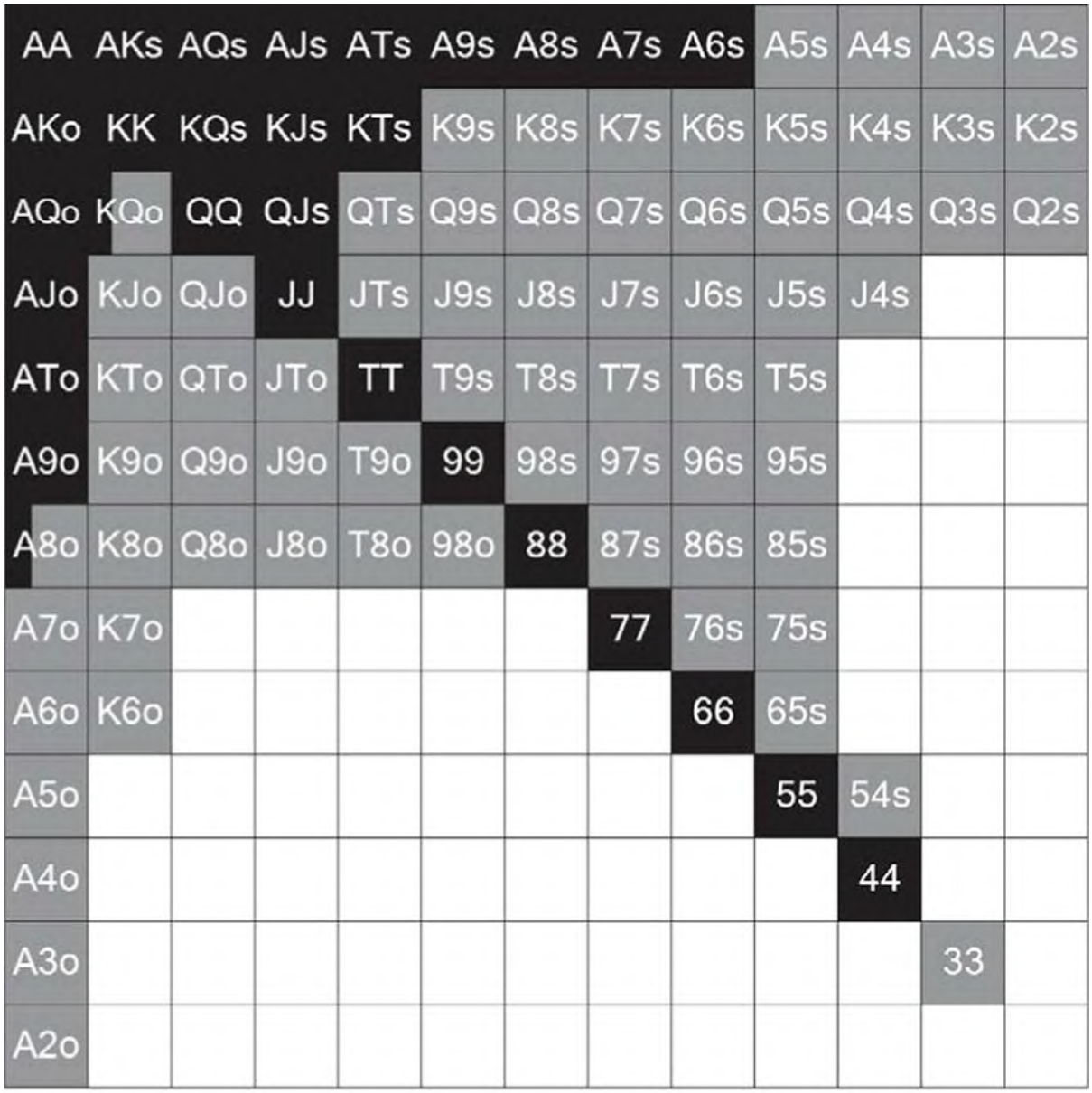
The bigger the effective stack that is being rejammed, the less frequently the opener has to defend. The earlier the position the player is going all-in from, the tighter the opener should defend, with the exception of the SB, which gets called lighter than the BB (this happens because the BB has the option to call, closing the action, so the rejamming range is stronger than the SB). When facing a rejam, the calling range should consist of the top x% of hands that have the highest equity vs the rejamming range according to the effective stacks *(Hand Ranges 267-294)*.



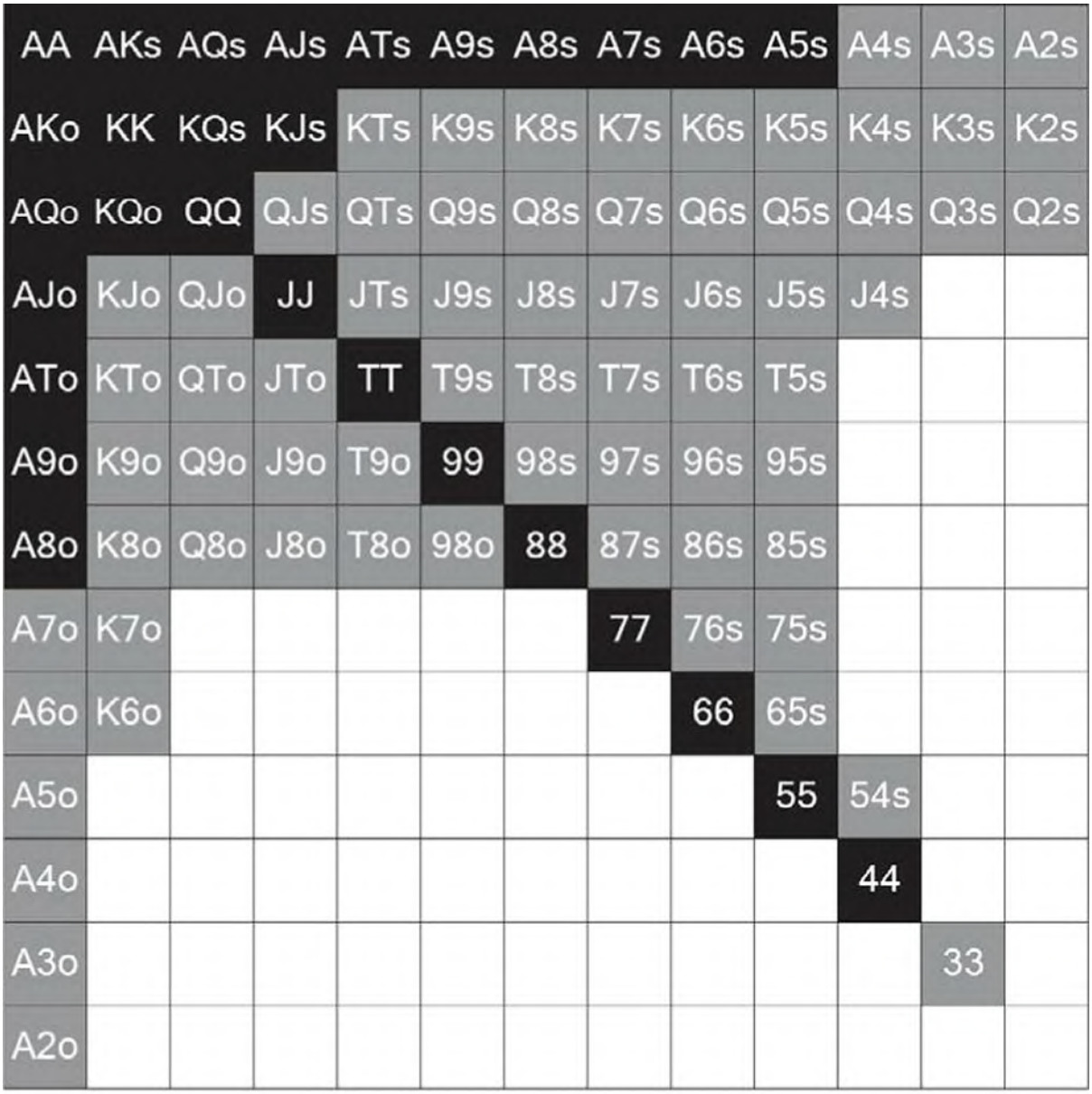
Hand Range 267: BN 15bb (2x vs BB All-in) • Call All-in 42.6% / • Fold 57.4%



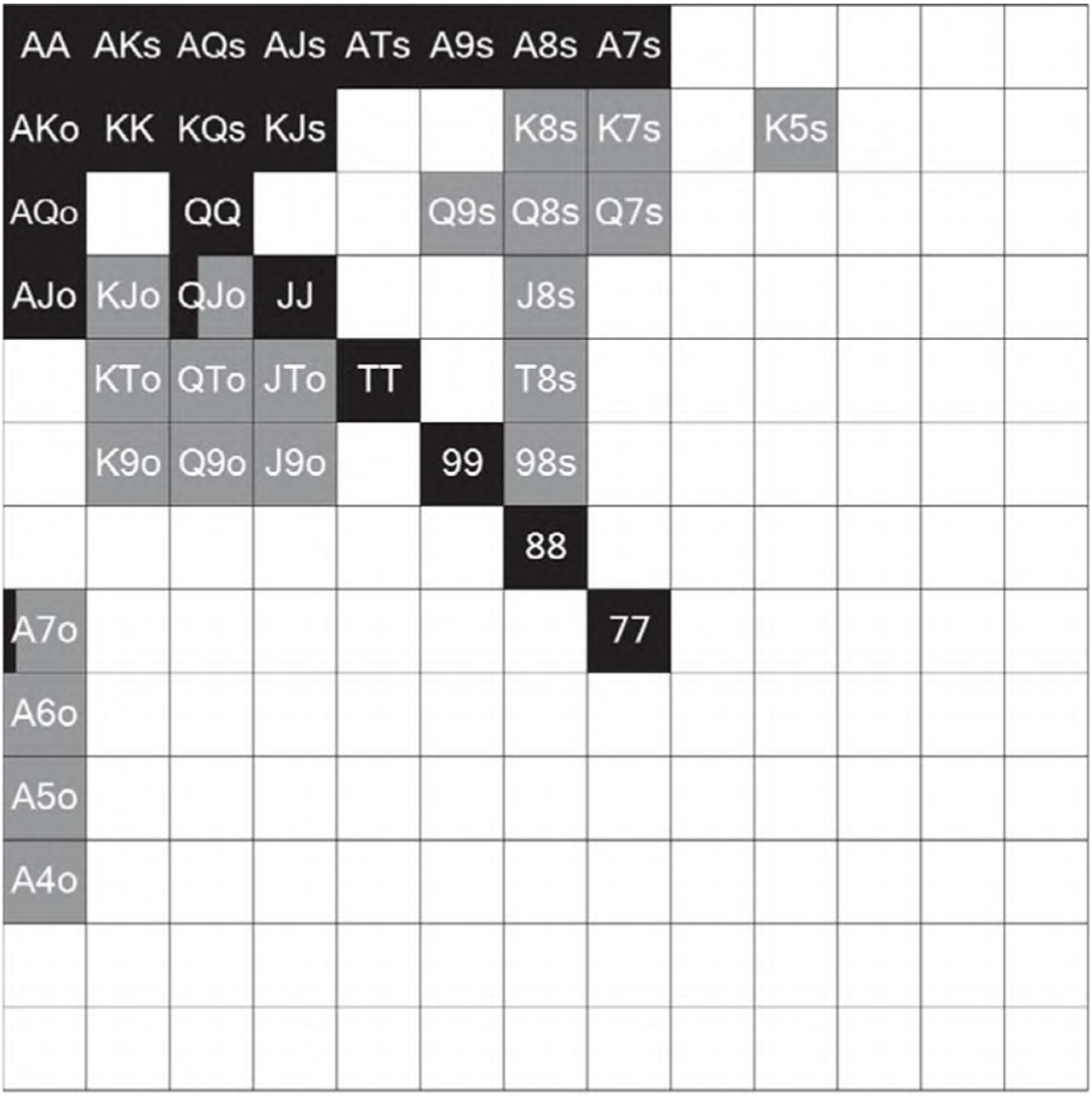
Hand Range 268: BN 15bb (2x vs SB All-in) • Call All-in 44.9% / • Fold 55.1%



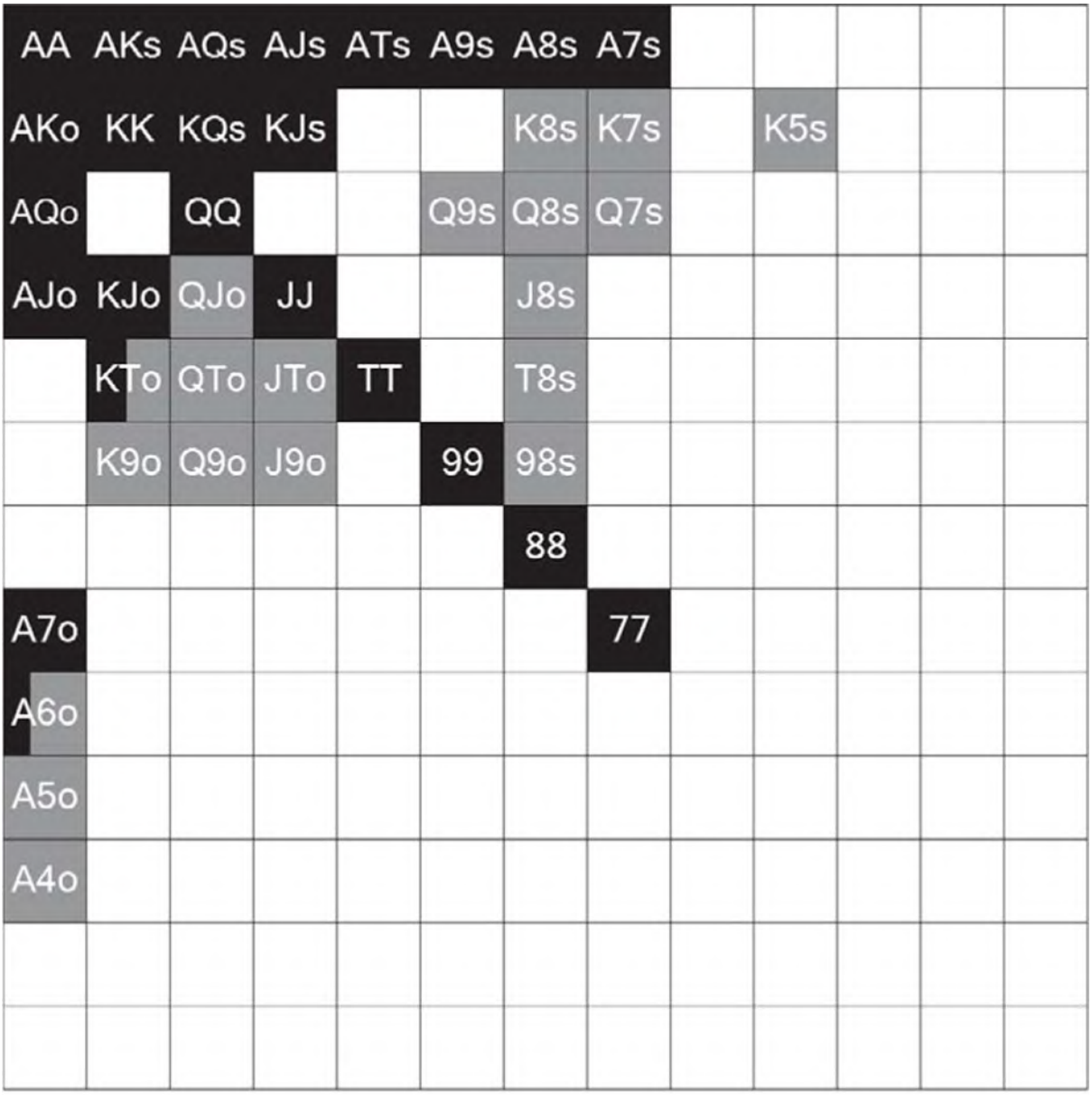
Hand Range 269: BN 25bb (2x vs BB All-in) • Call All-in 29.5% / • Fold 70.5%



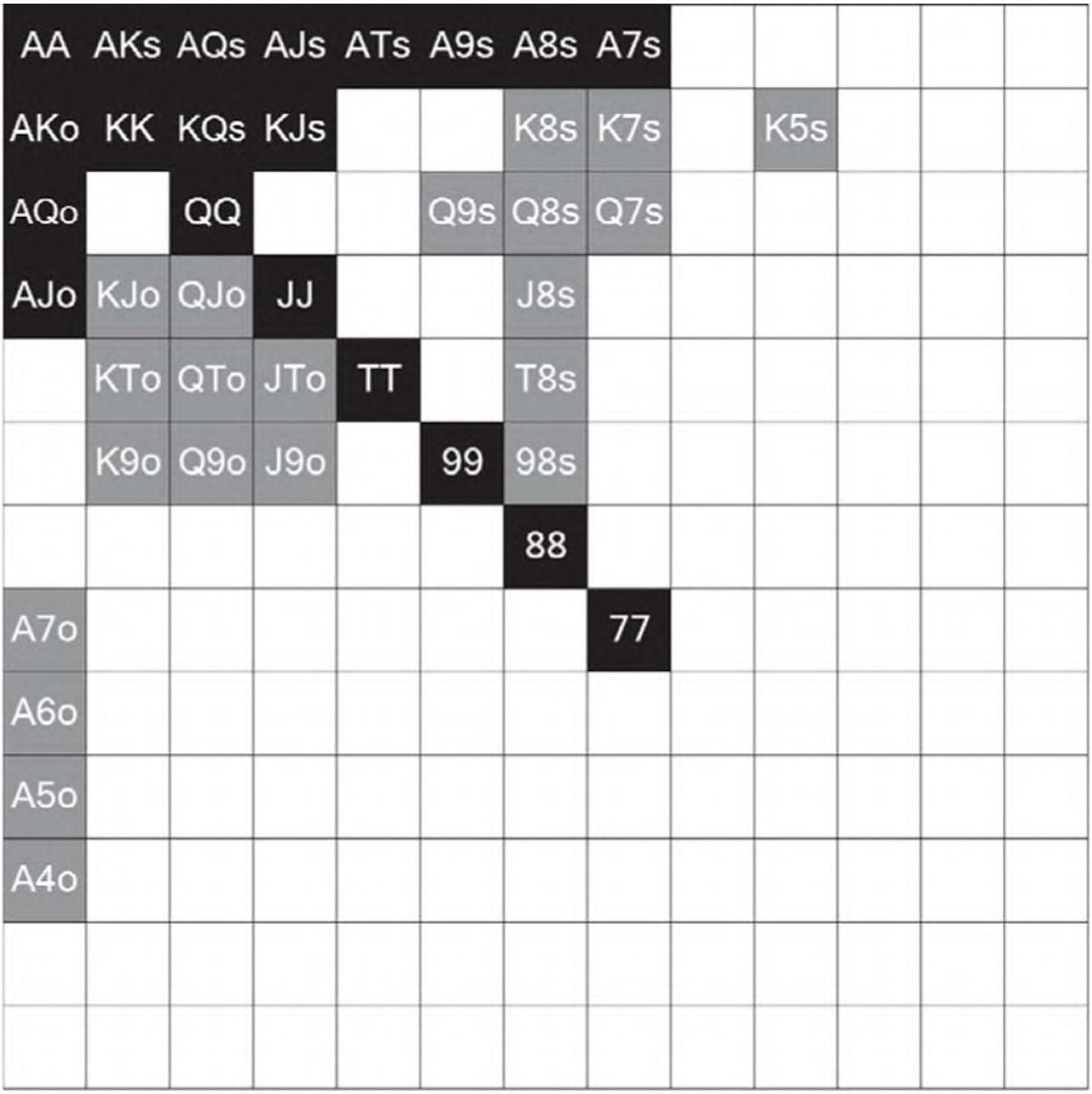
Hand Range 270: BN 25bb (2x vs SB All-in) • Call All-in 31.6% / • Fold 68.4%



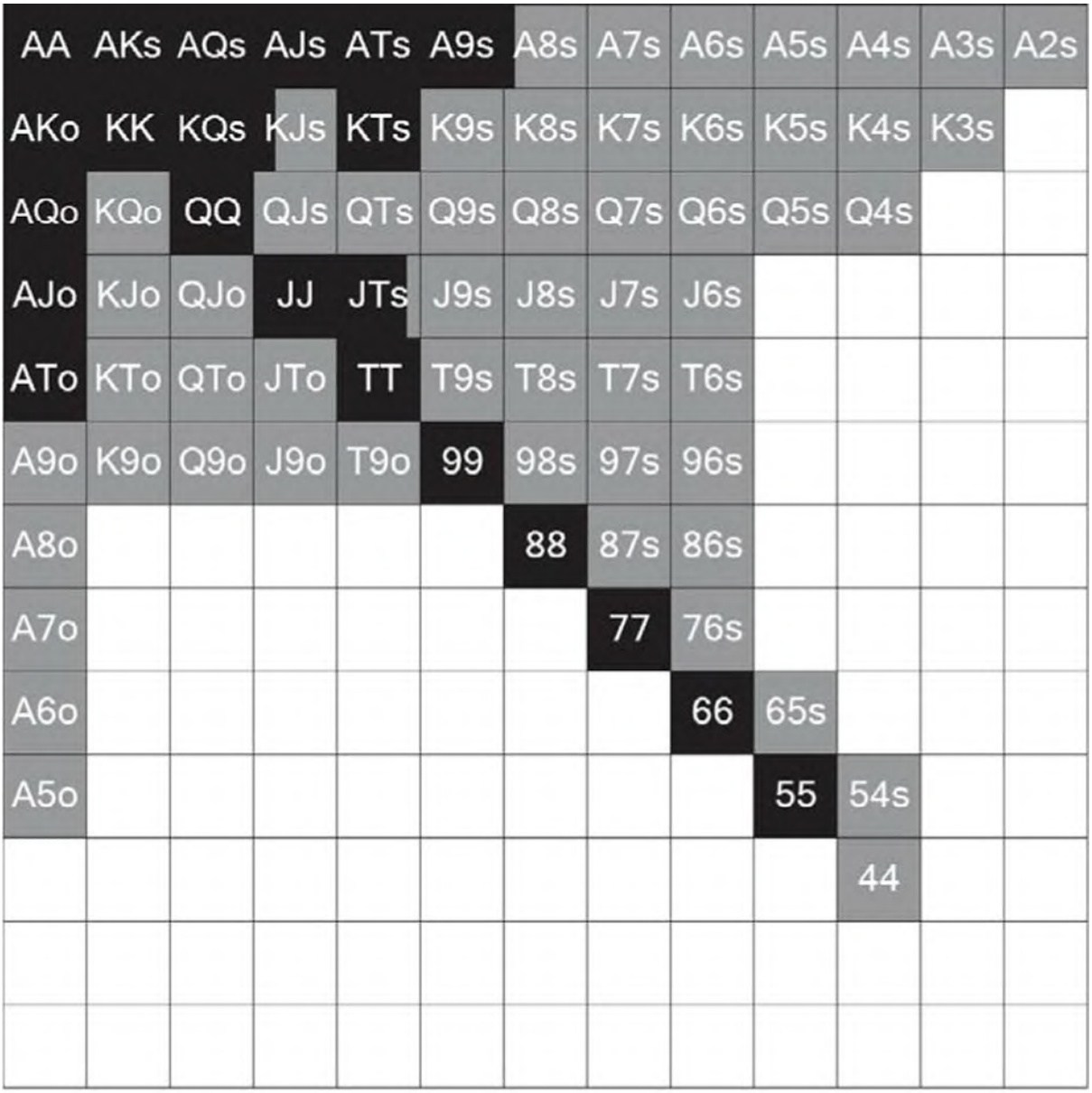
Hand Range 271: CO 15bb (2x vs BB All-in) • Call All-in 45.1% / • Fold 54.9%



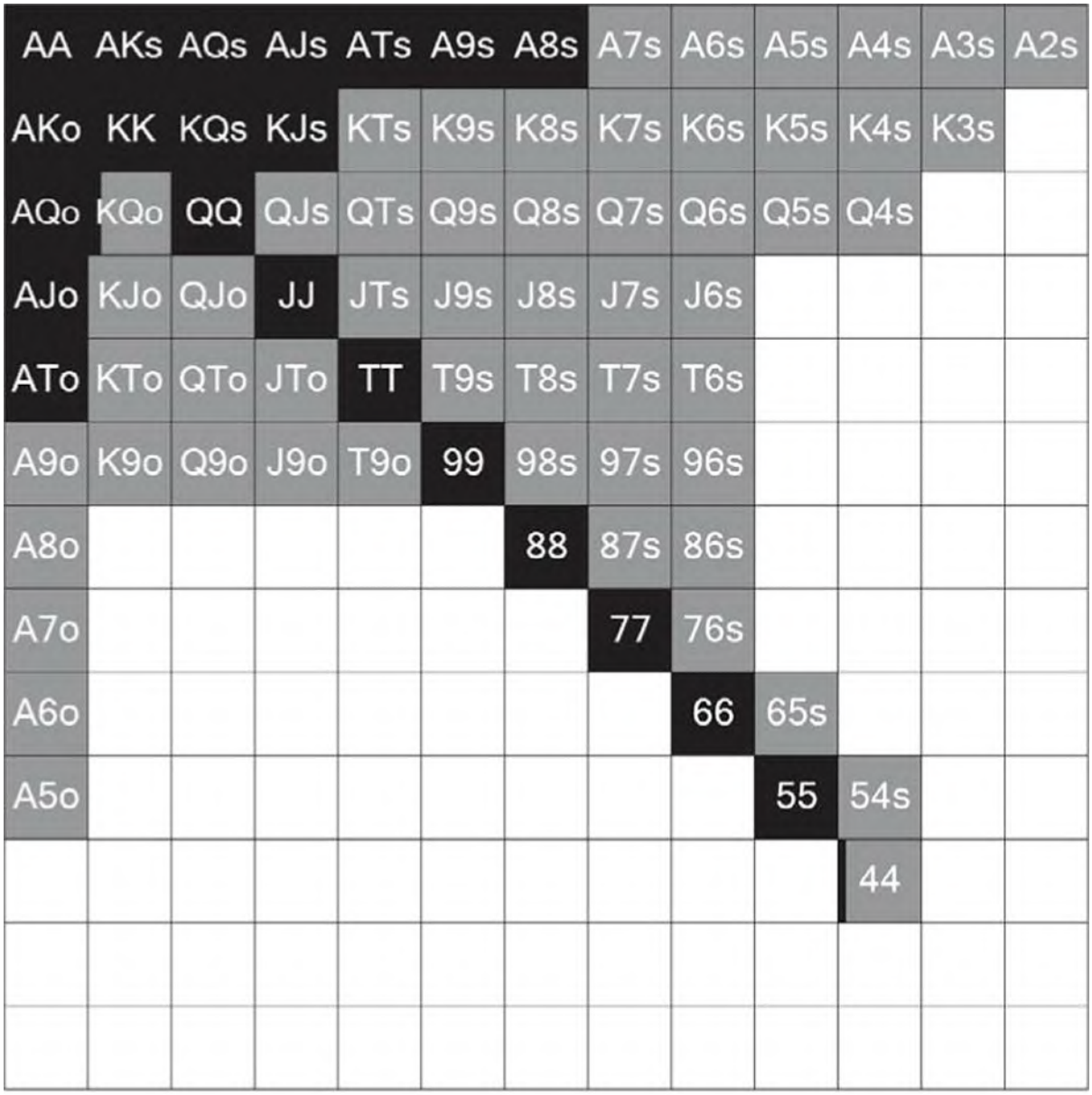
Hand Range 272: CO 15bb (2x vs SB All-in) • Call All-in 50.2% / • Fold 49.8%



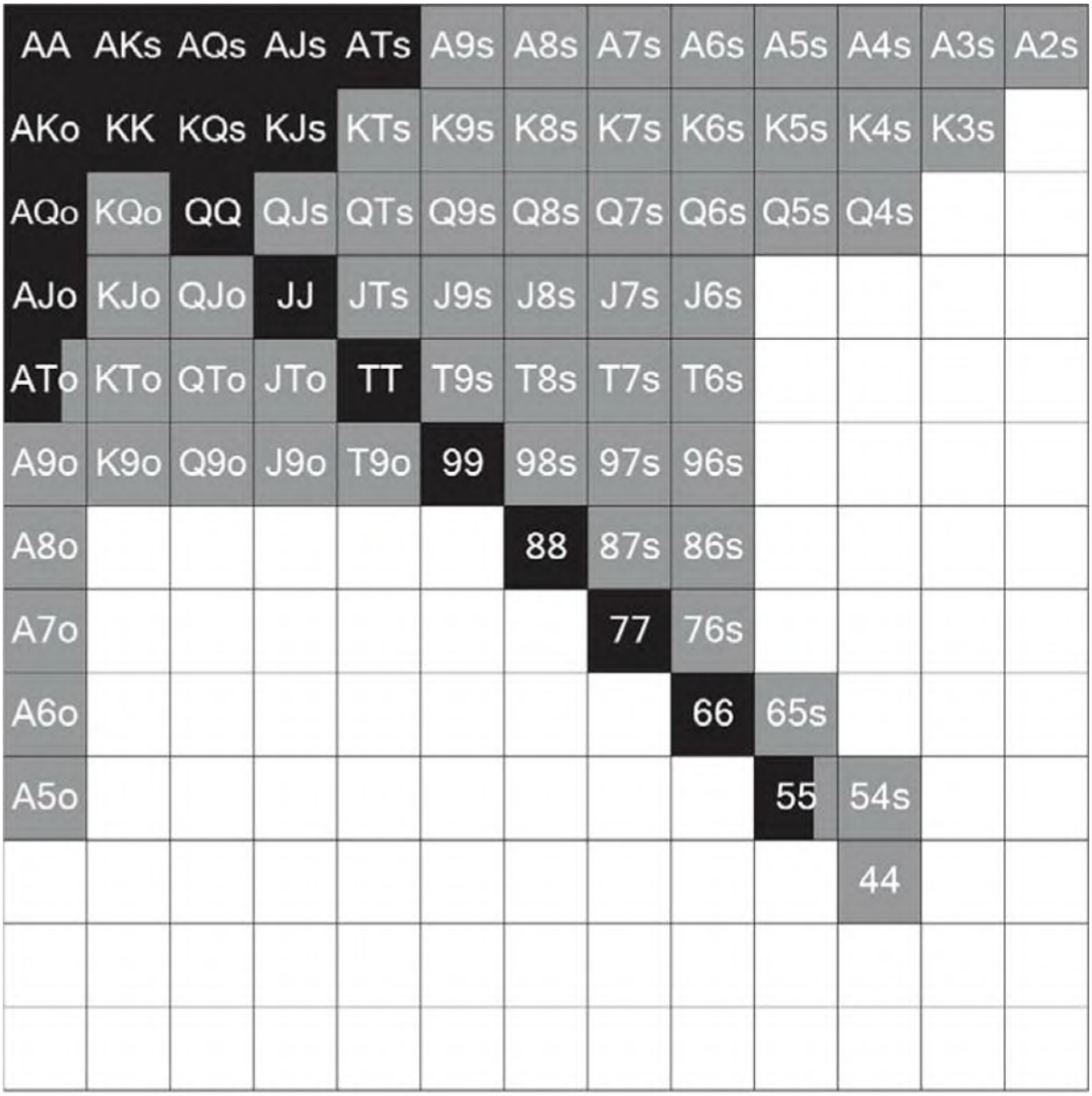
Hand Range 273: CO 15bb (2x vs BN All-in) • Call All-in 43.8% / • Fold 56.2%



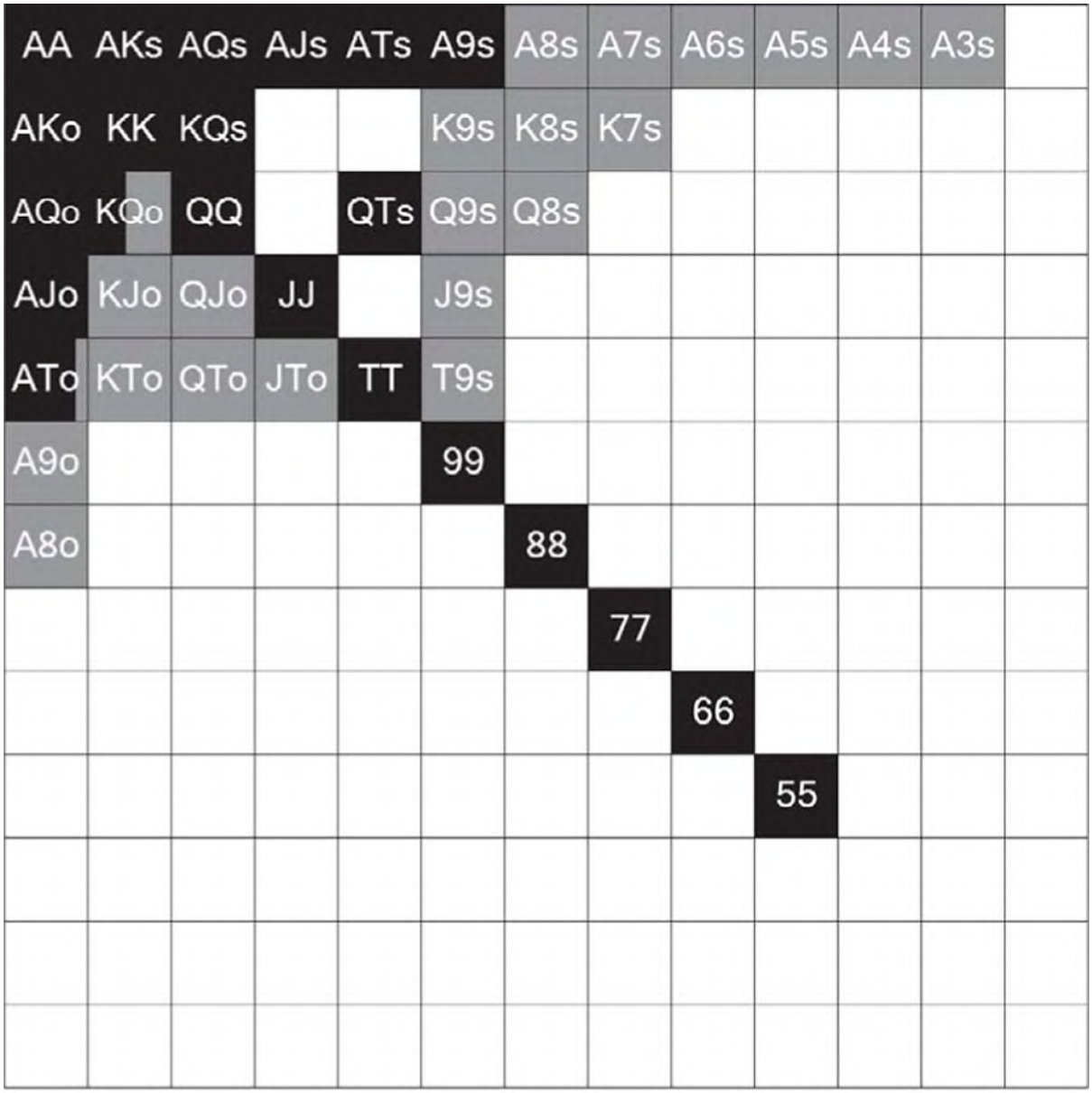
Hand Range 274: CO 25bb (2x vs BB All-in) • Call All-in 31% / • Fold 69%



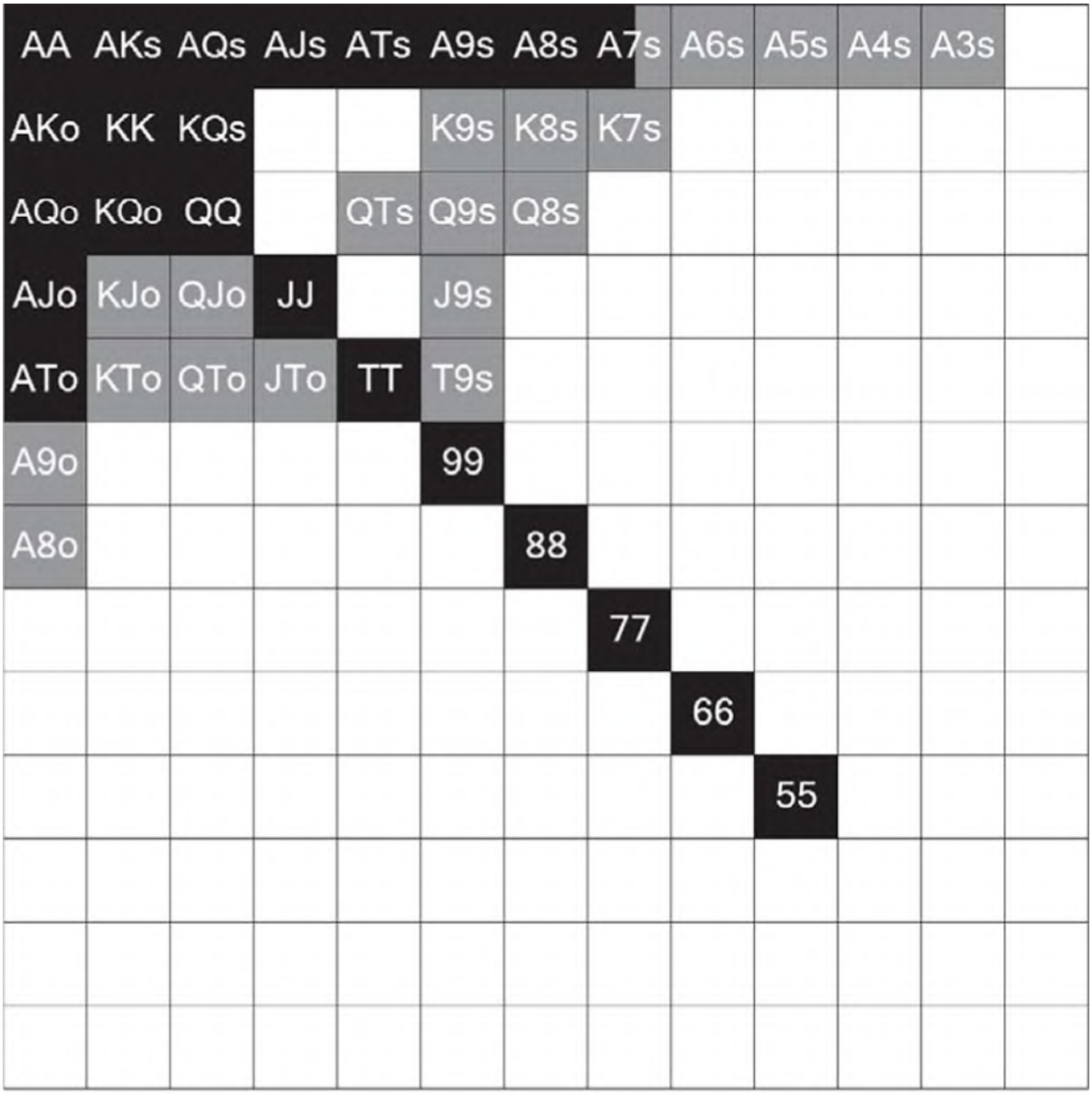
Hand Range 275: CO 25bb (2x vs SB All-in) • Call All-in 31.3% / • Fold 68.7%



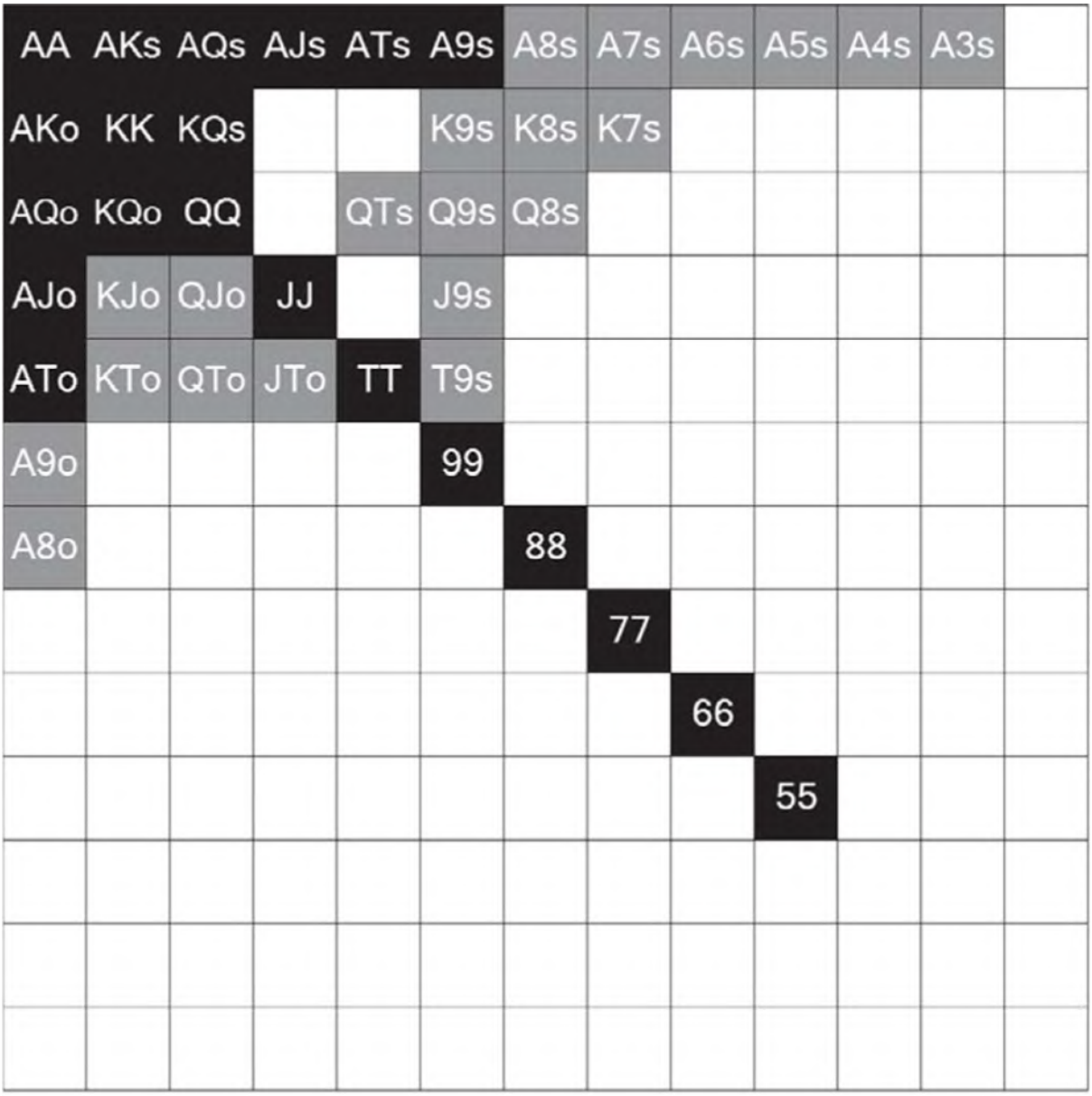
Hand Range 276: CO 25bb (2x vs BN All-in) • Call All-in 31.6% / • Fold 68.4%



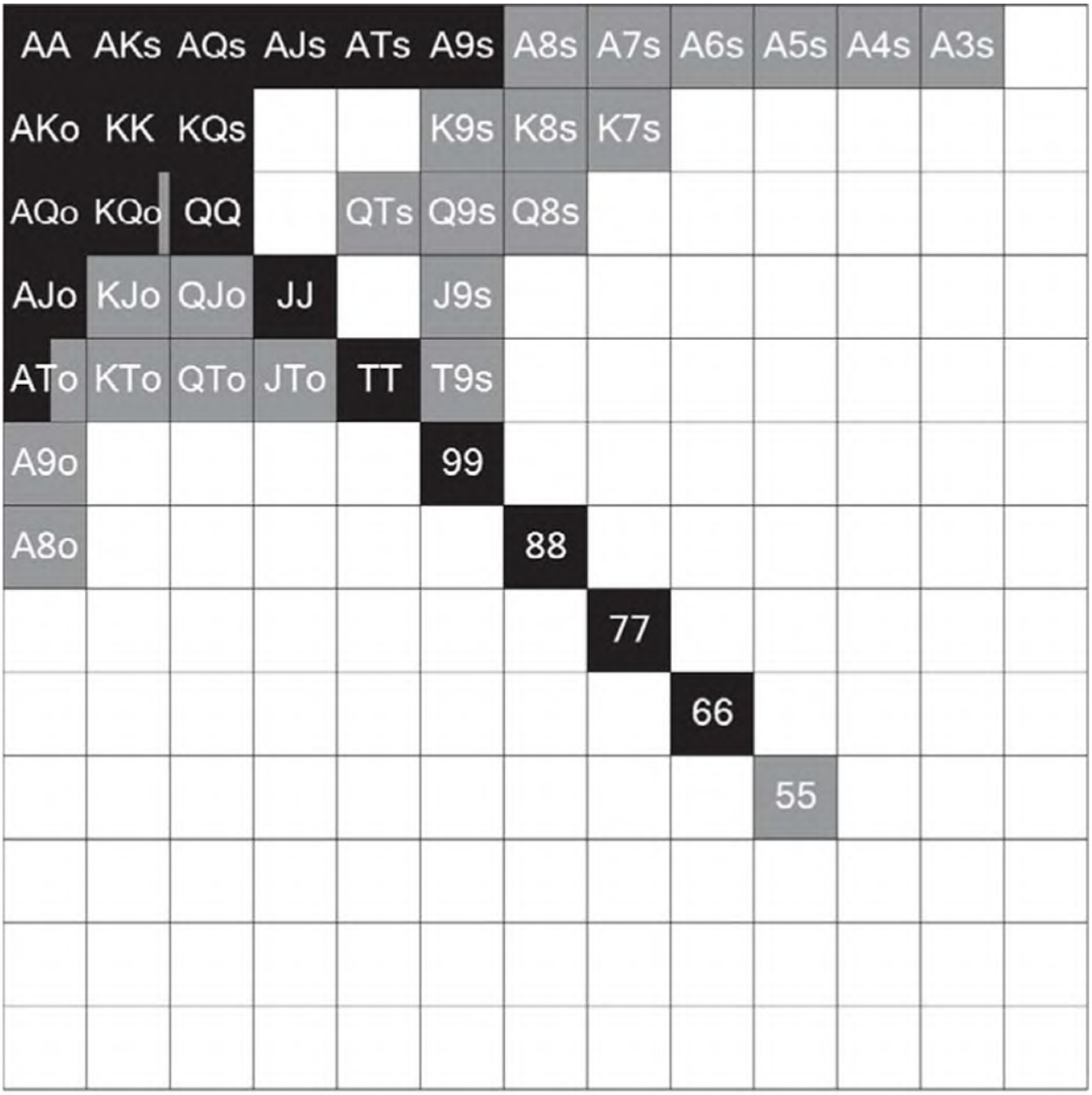
Hand Range 277: LJ 15bb (2x vs BB All-in) • Call All-in 47.9% / • Fold 52.1%



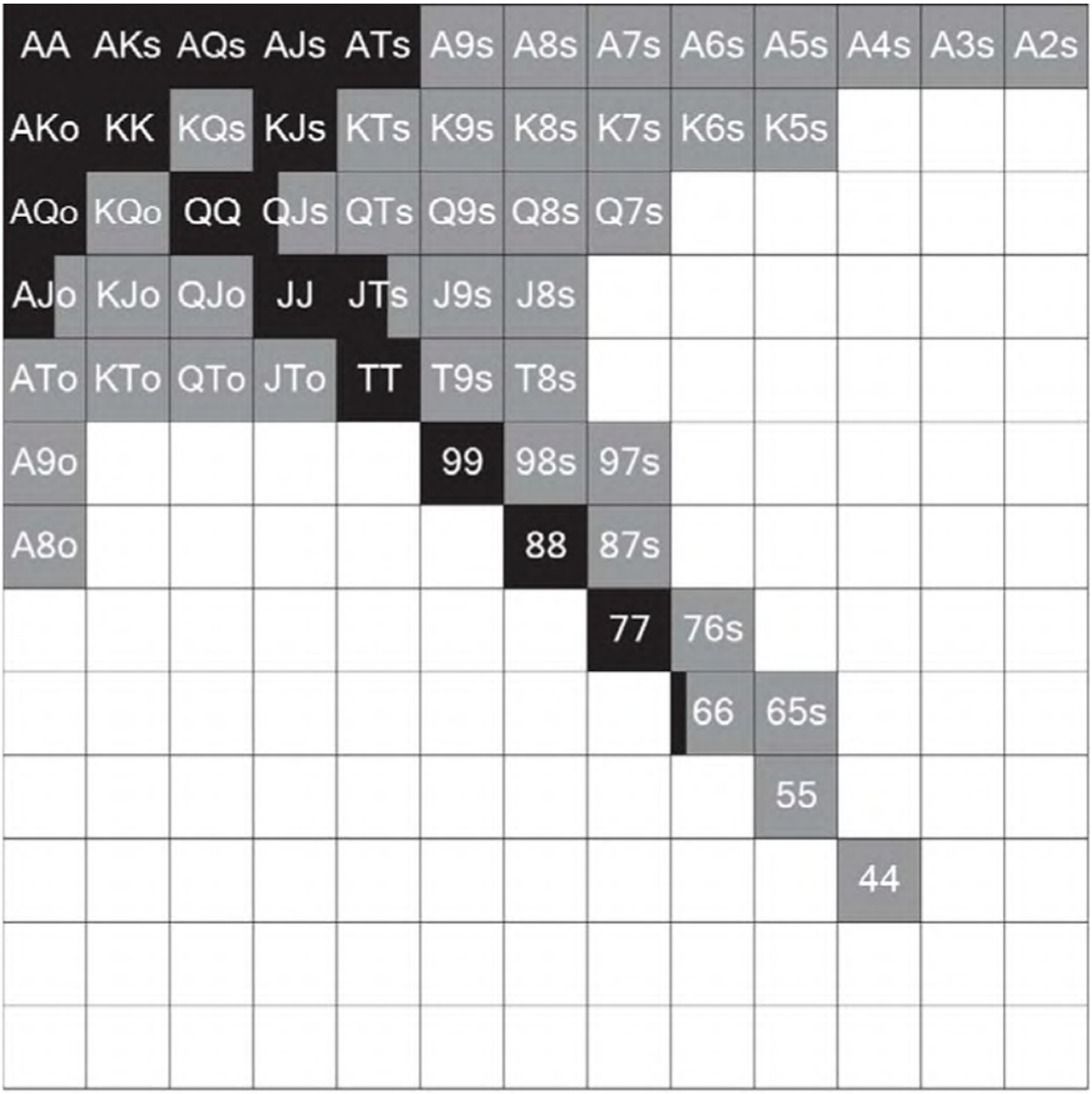
Hand Range 278: LJ 15bb (2x vs SB All-in) • Call All-in 51.3% / • Fold 48.7%



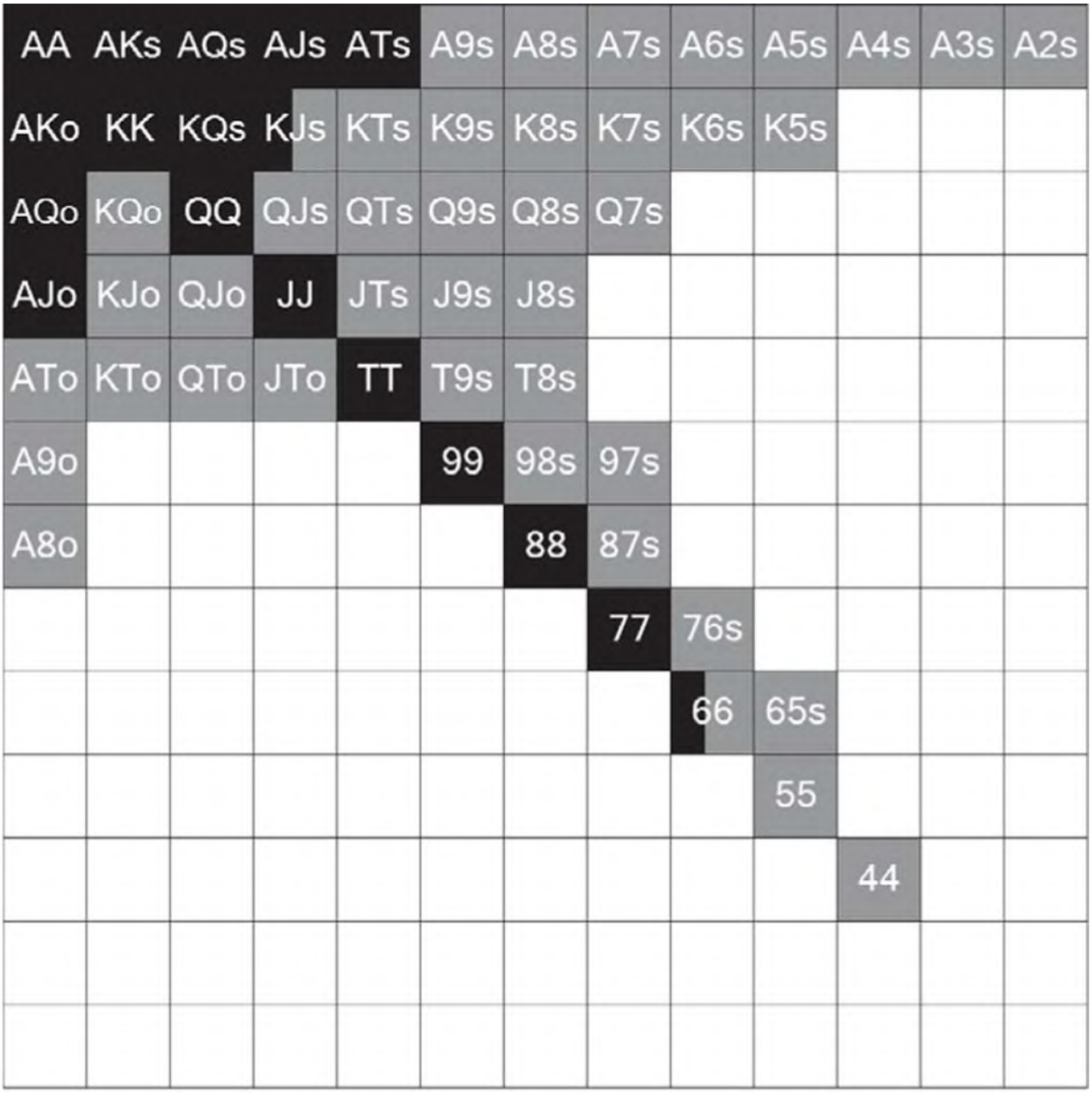
Hand Range 279: LJ 15bb (2x vs BN All-in) • Call All-in 51% / • Fold 49%



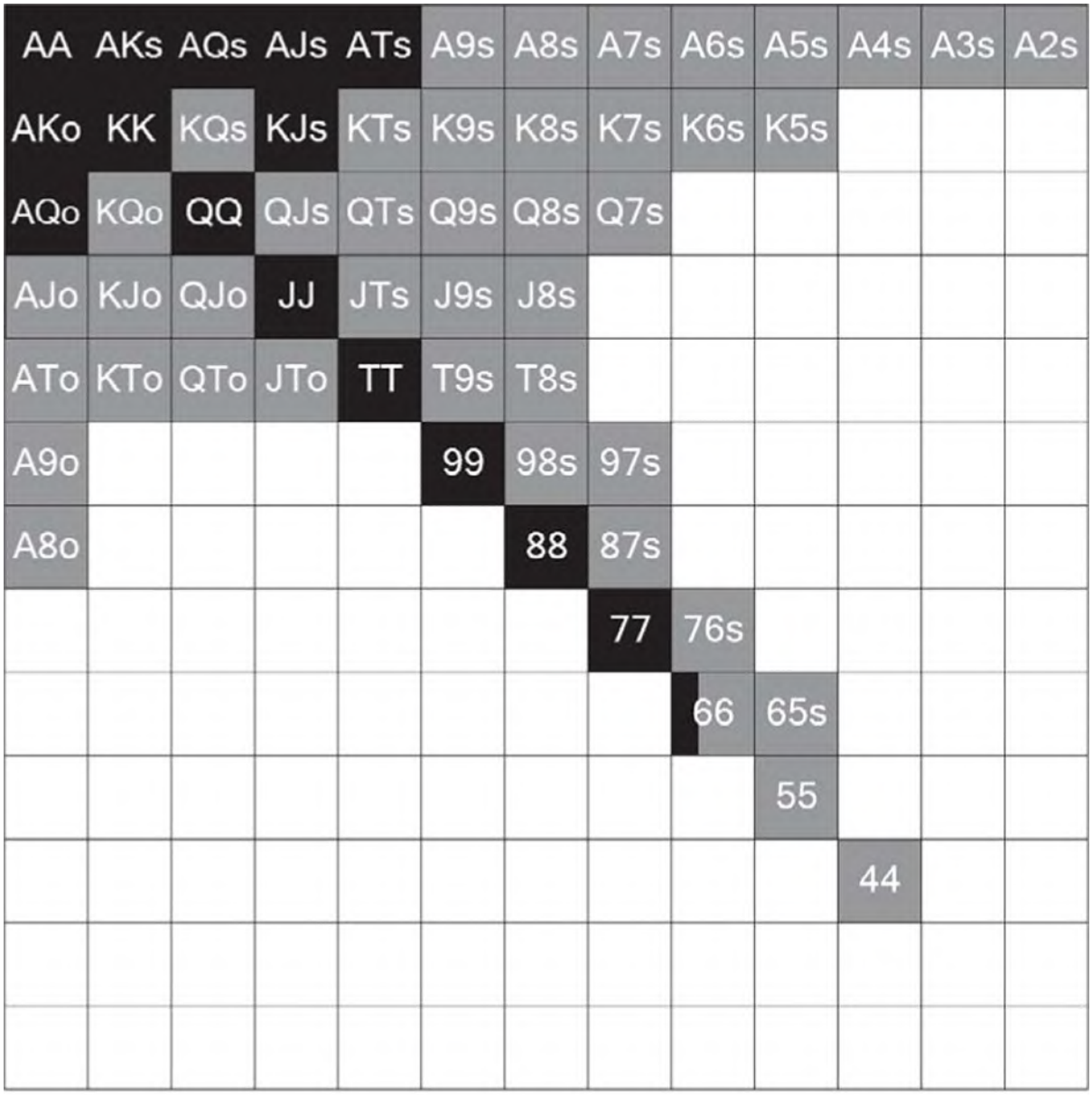
Hand Range 280: LJ 15bb (2x vs HJ All-in) • Call All-in 46.2% / • Fold 53.8%



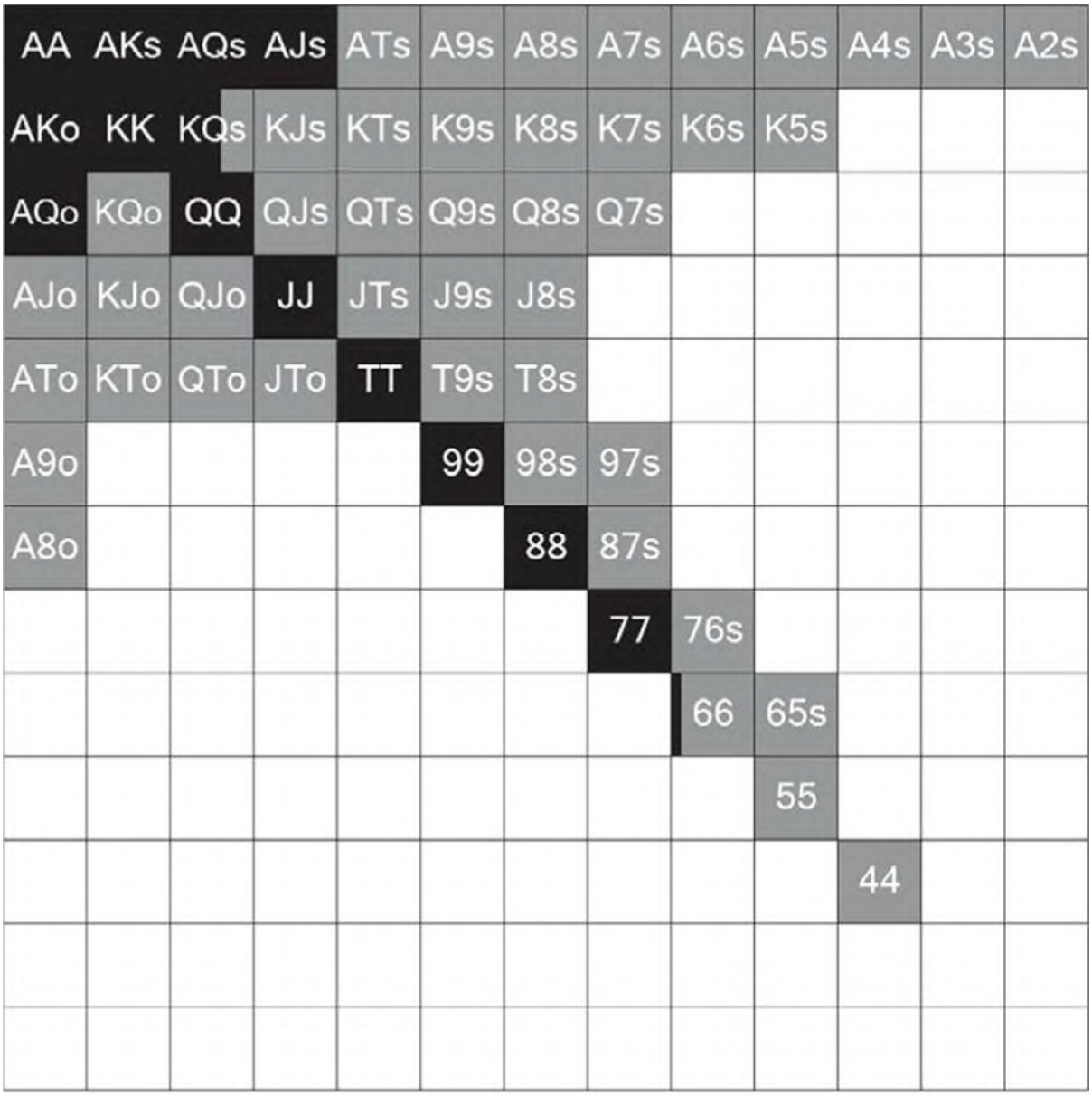
Hand Range 281: LJ 25bb (2x vs BB All-in) • Call All-in 32.5% / • Fold 67.5%



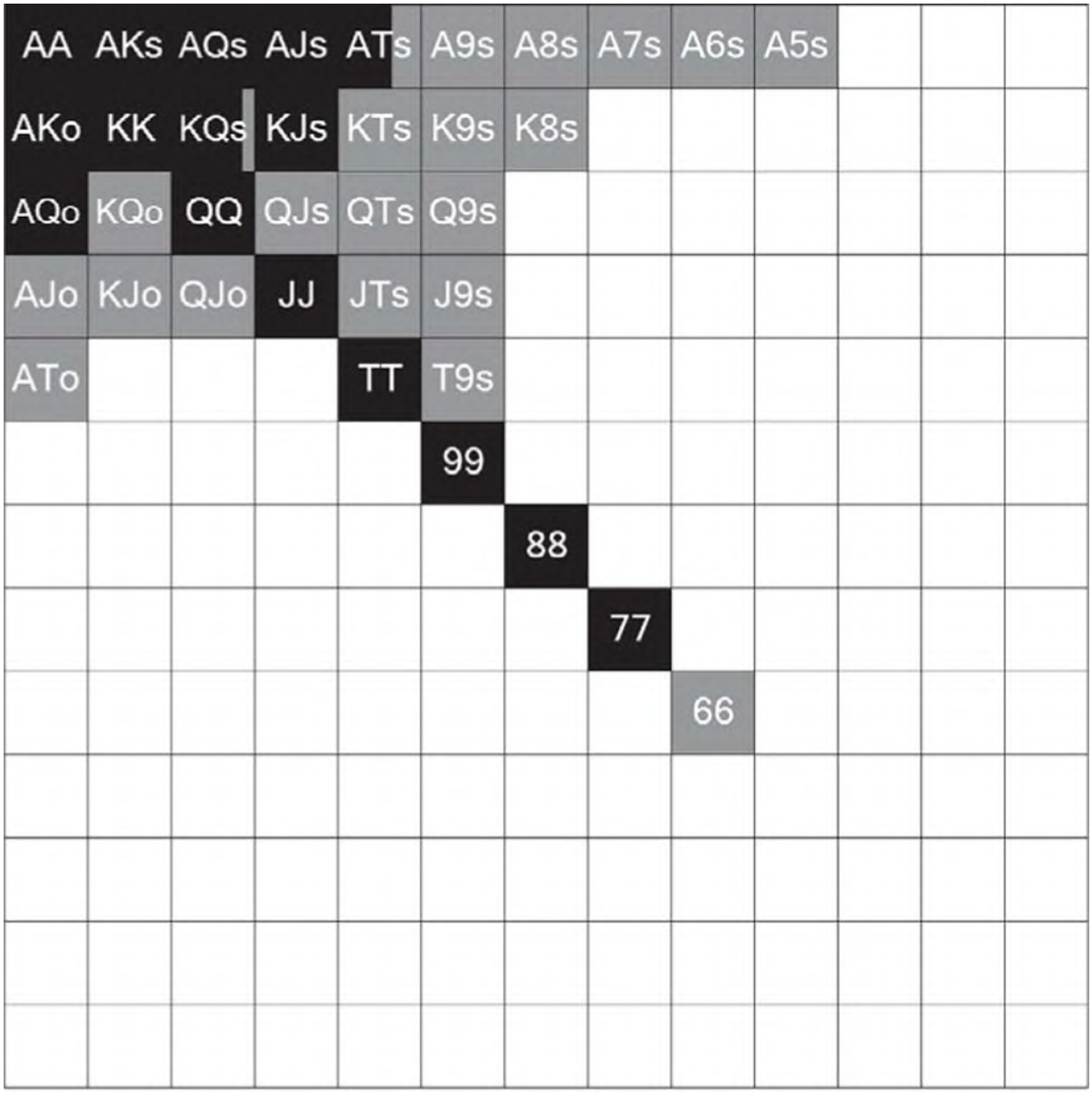
Hand Range 282: LJ 25bb (2x vs SB All-in) • Call All-in 33.9% / • Fold 66.1%



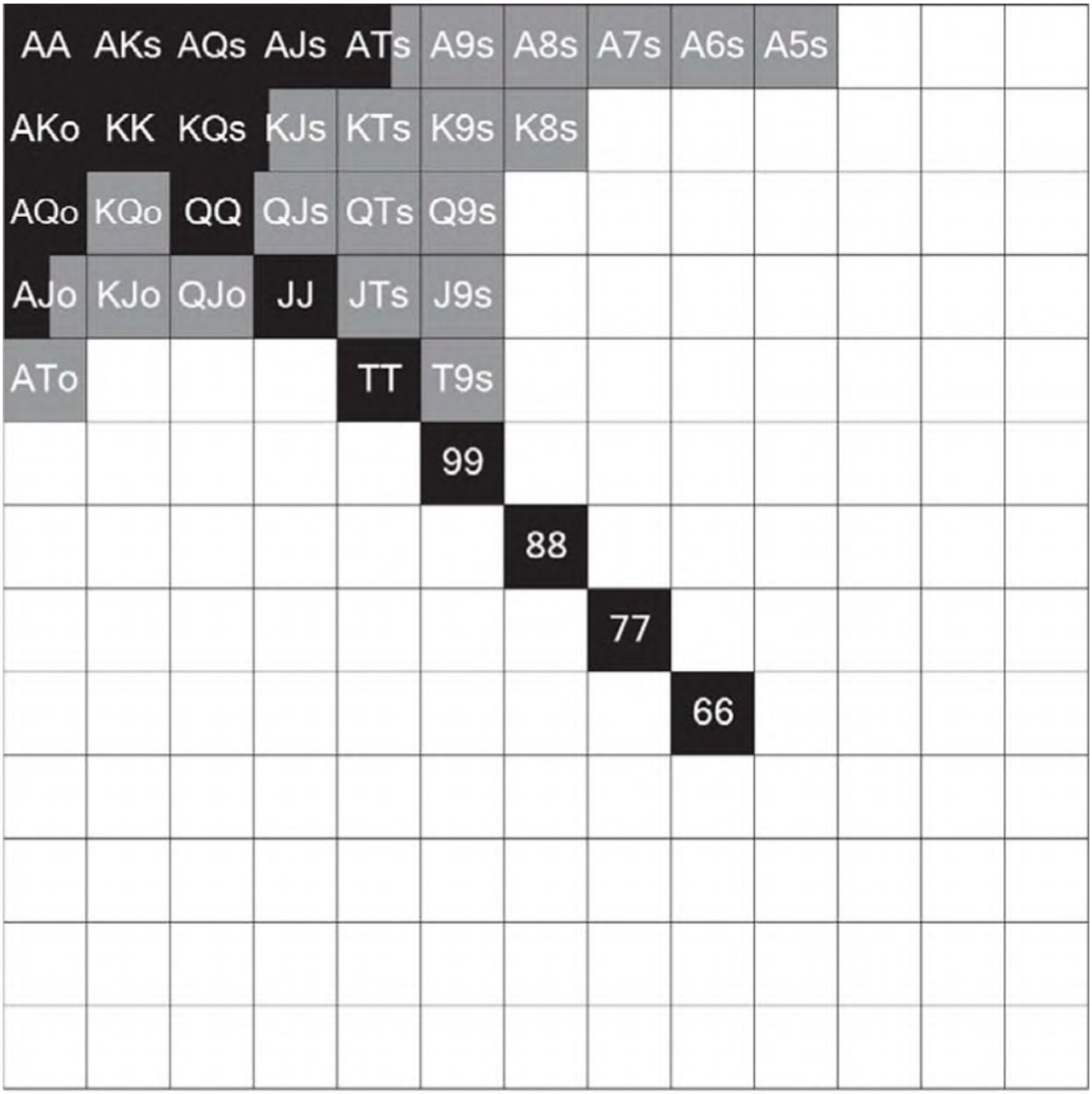
Hand Range 283: LJ 25bb (2x vs BN All-in) • Call All-in 29.4% / • Fold 70.6%



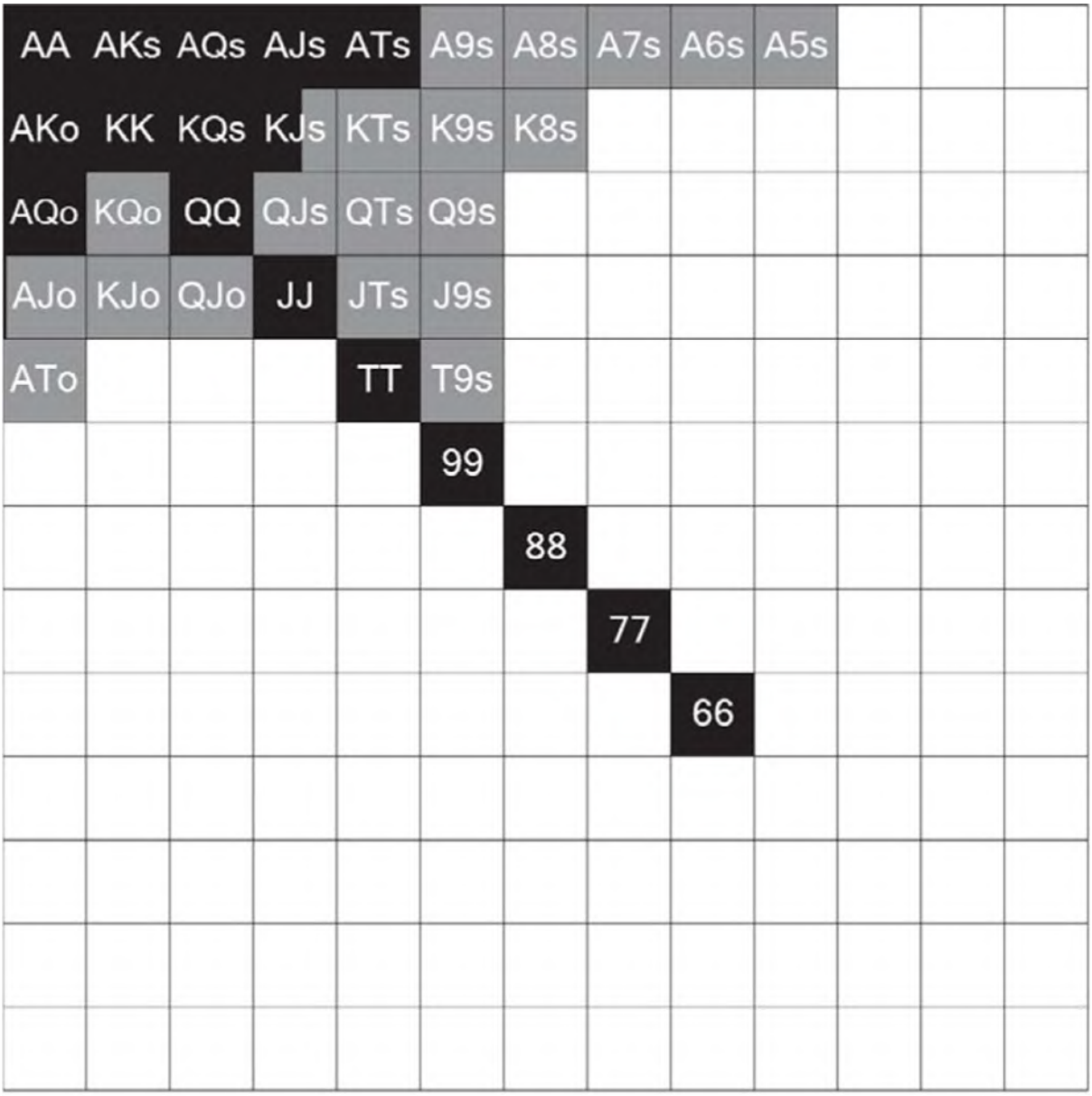
Hand Range 284: LJ 25bb (2x vs HJ All-in) • Call All-in 27.2% / • Fold 72.8%



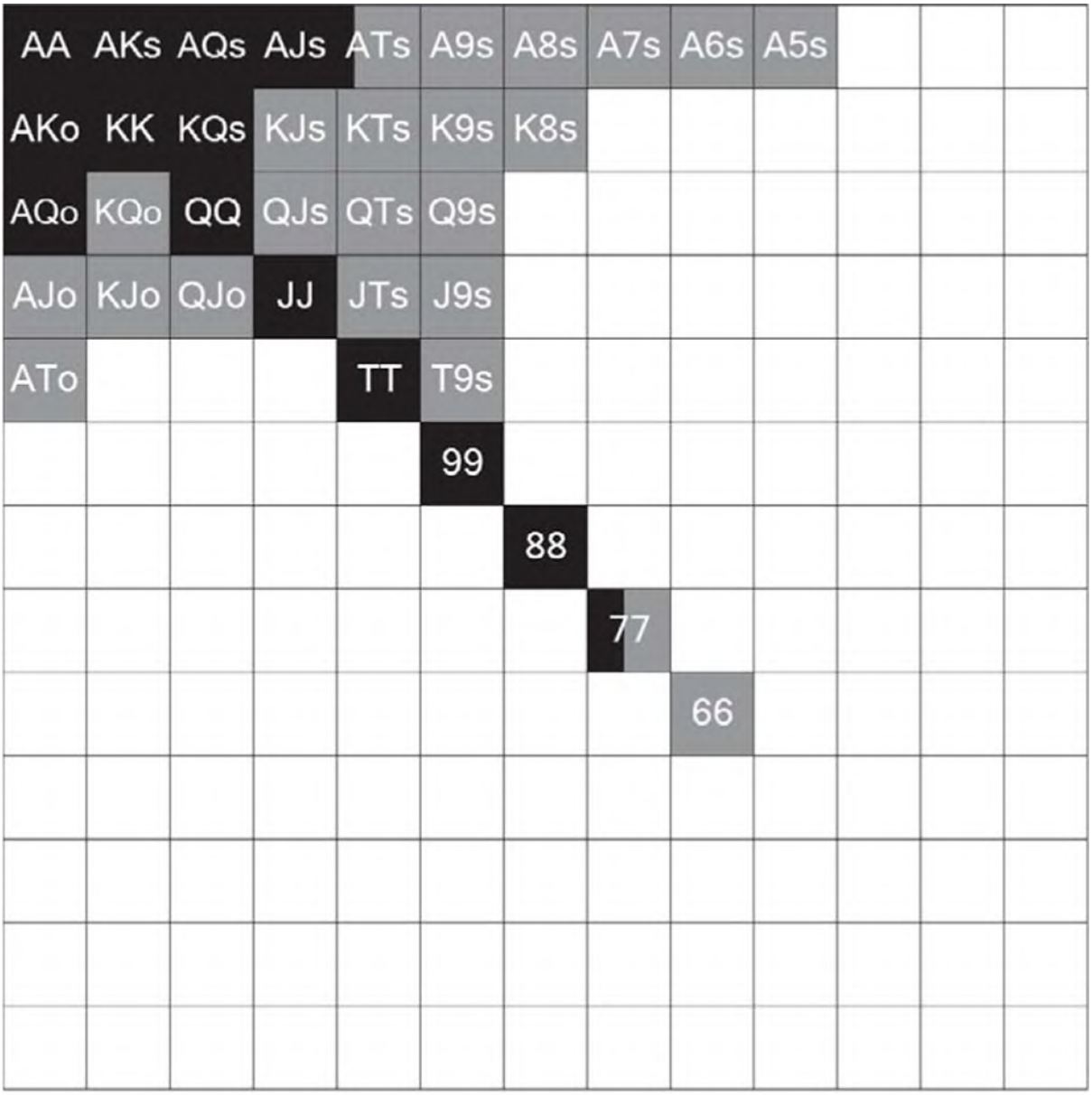
Hand Range 285: UTG 15bb (2x vs BB All-in) • Call All-in 50.3% / • Fold 49.7%



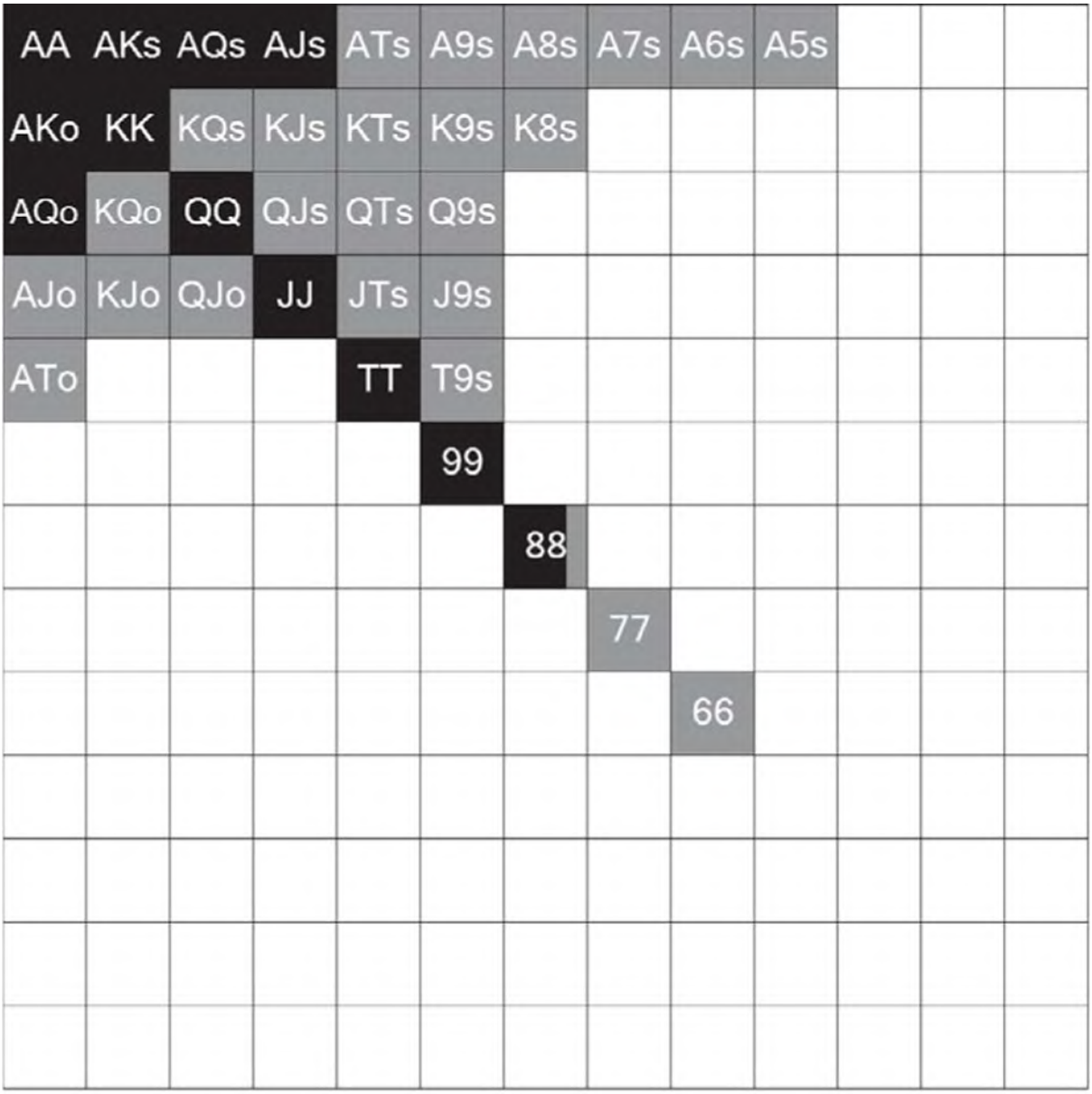
Hand Range 286: UTG 15bb (2x vs SB All-in) • Call All-in 52.9% / • Fold 47.1%



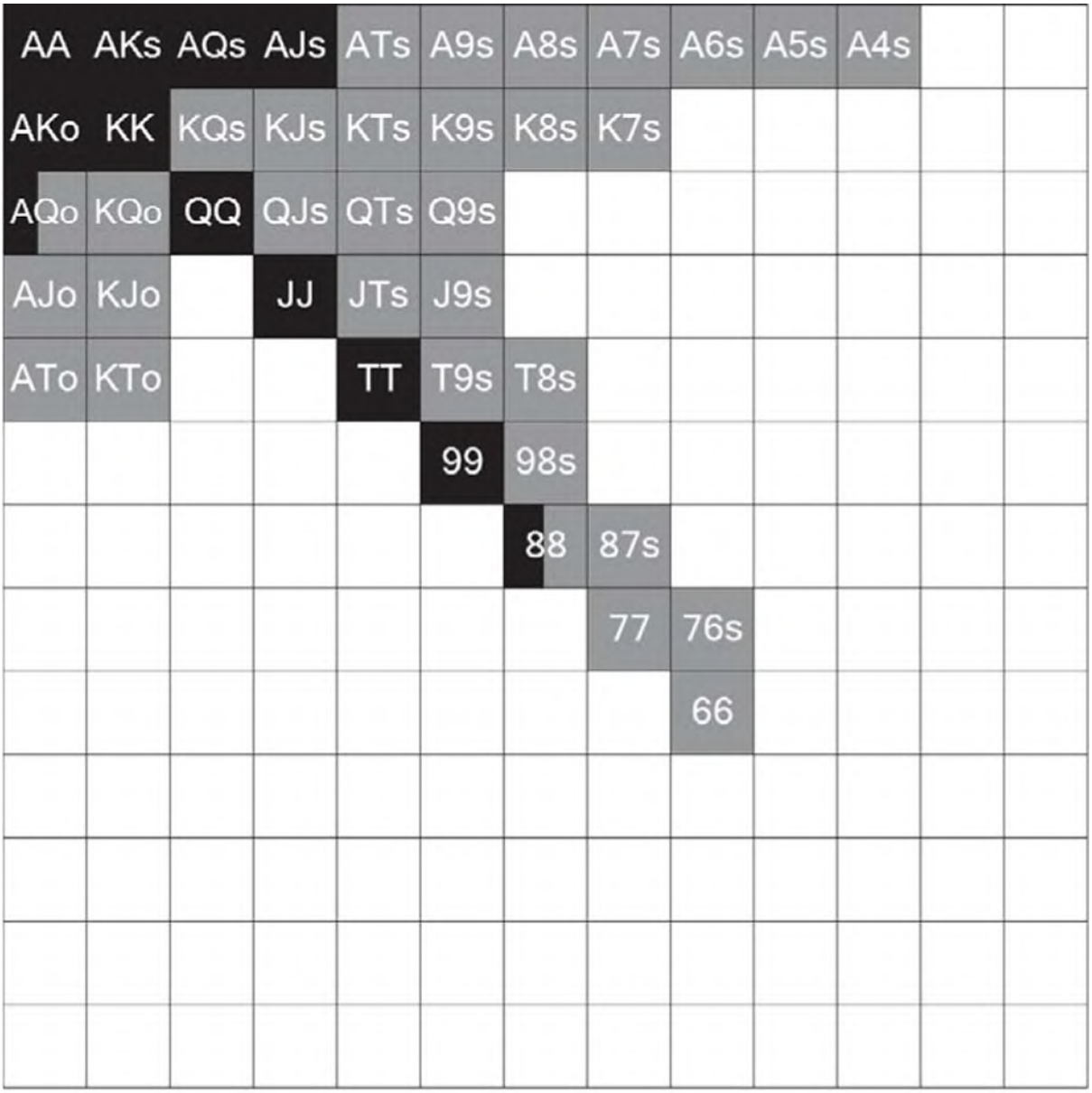
Hand Range 287: UTG 15bb (2x vs BN All-in) • Call All-in 51.1% / • Fold 48.9%



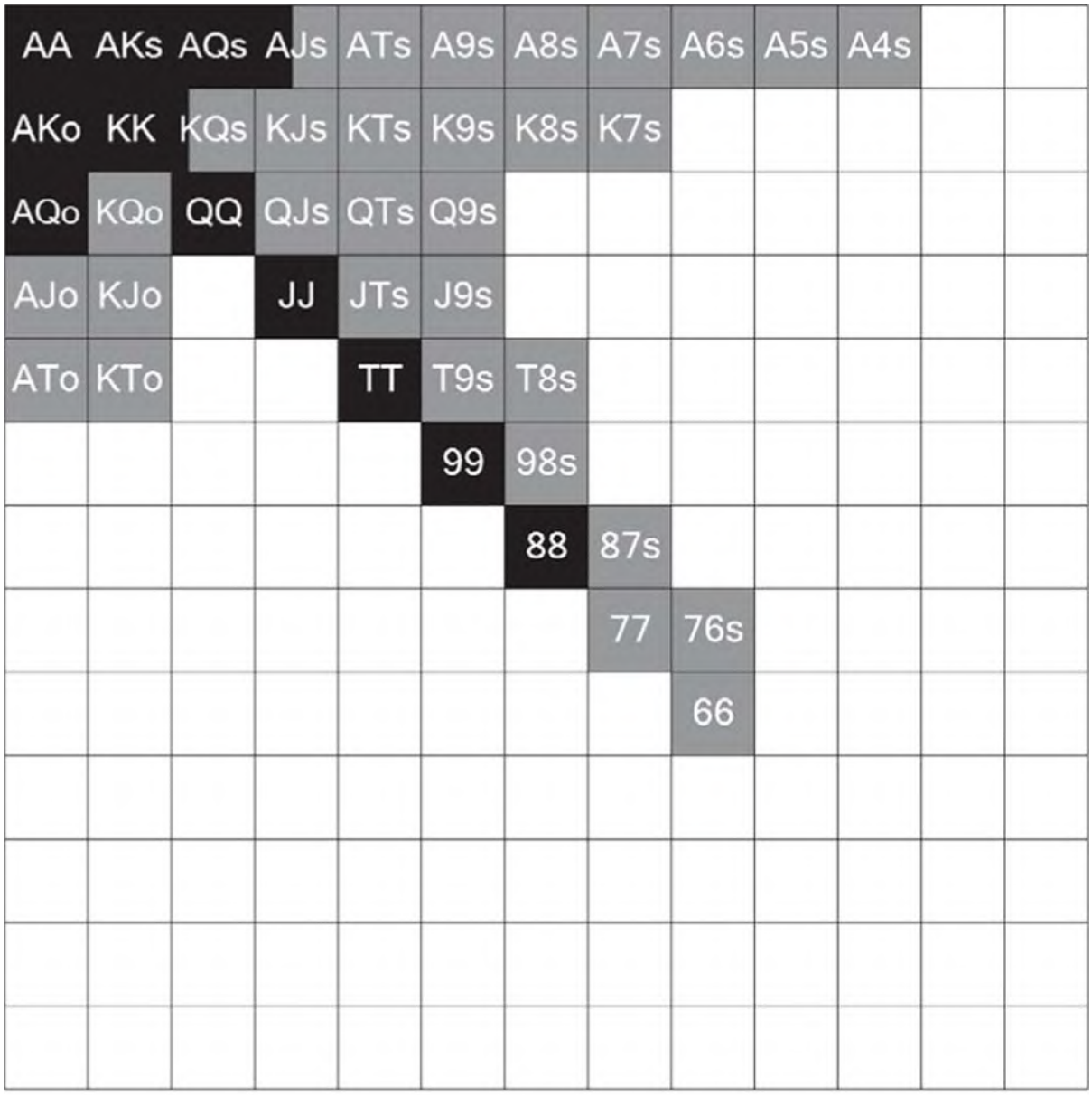
Hand Range 288: UTG 15bb (2x vs HJ All-in) • Call All-in 45.7% / • Fold 54.3%



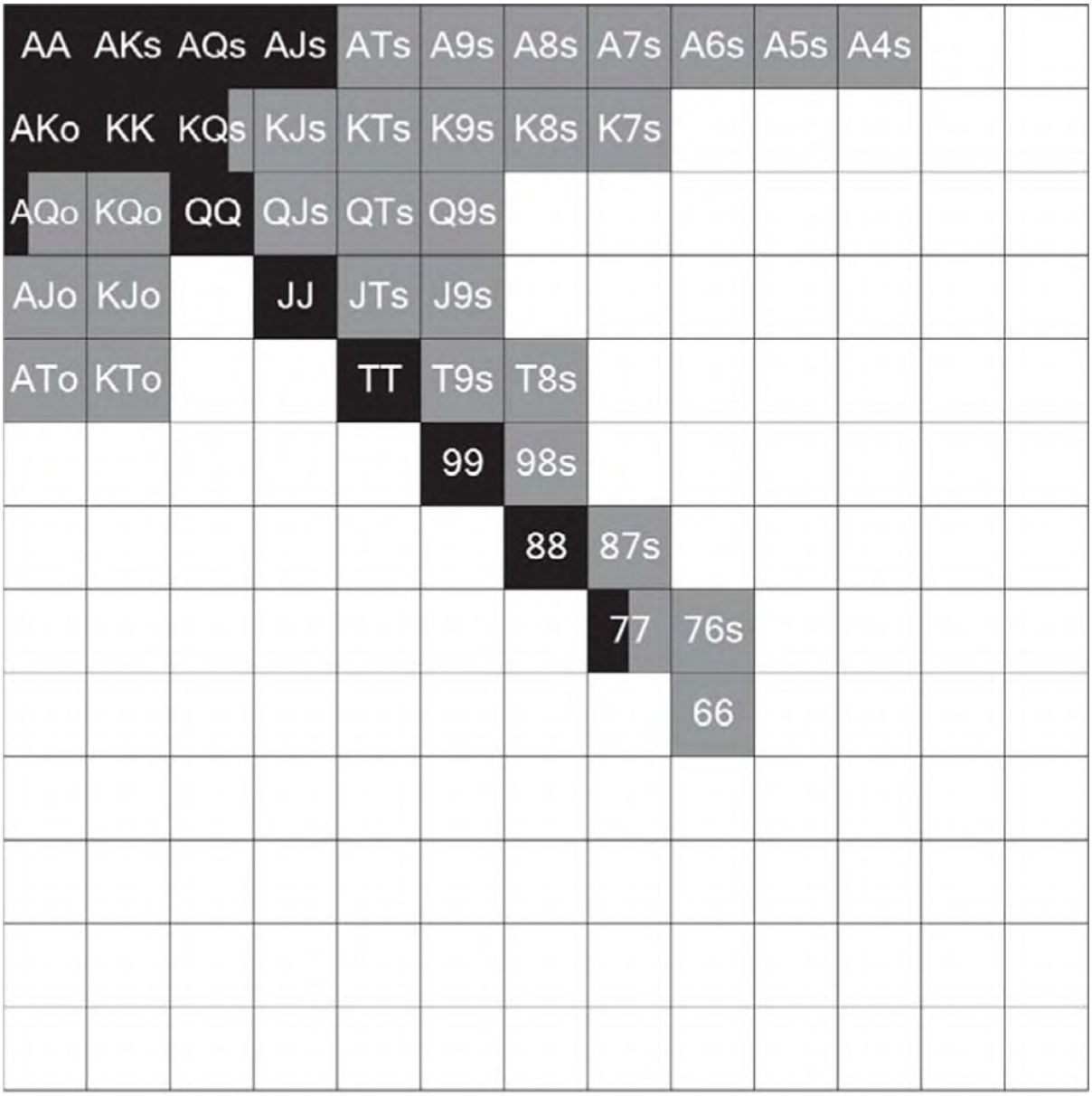
Hand Range 289: UTG 15bb (2x vs UTG+1 All-in) • Call All-in 41% / • Fold 59%



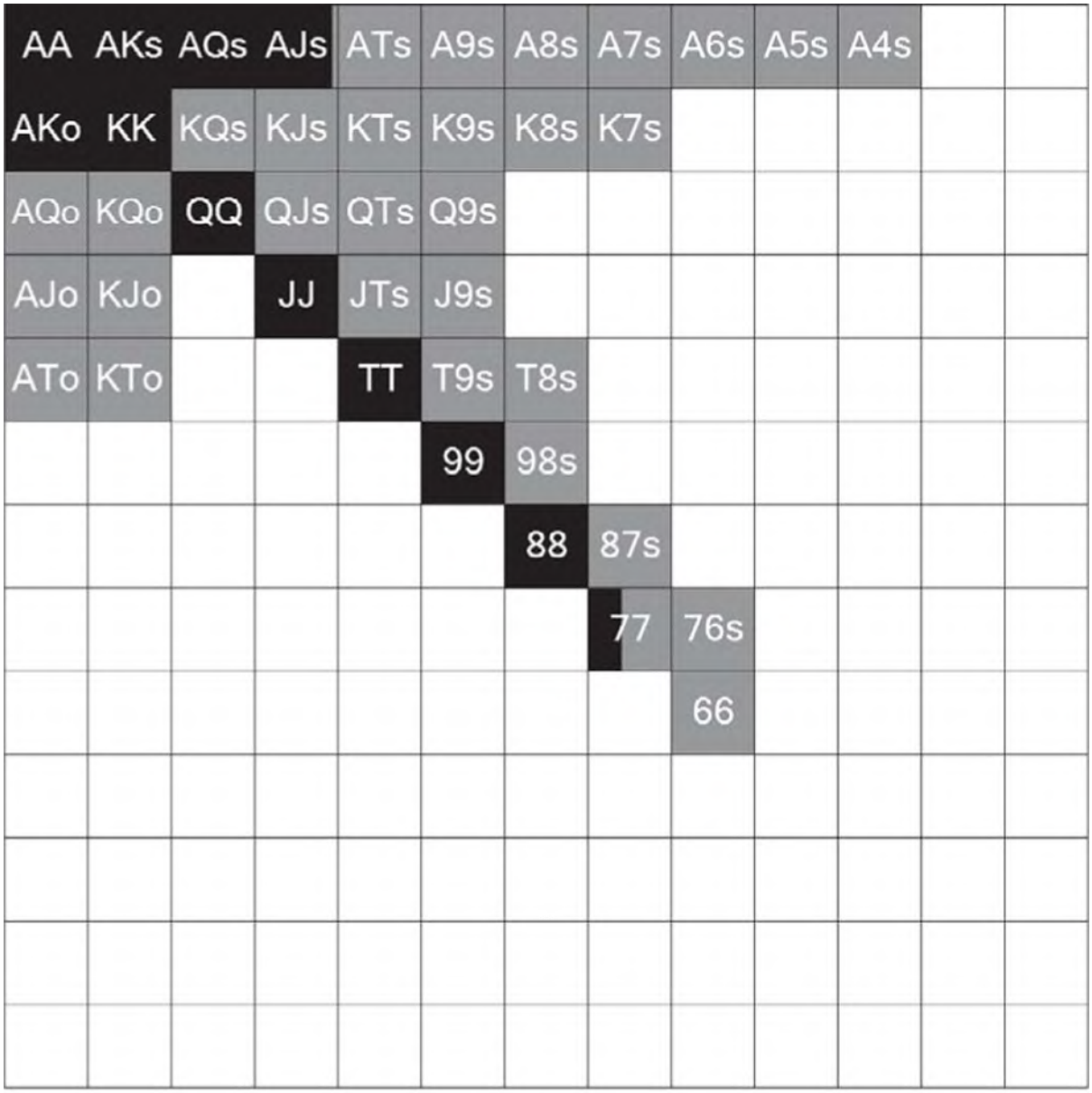
Hand Range 290: UTG 25bb (2x vs BB All-in) • Call All-in 30.5% / • Fold 69.5%



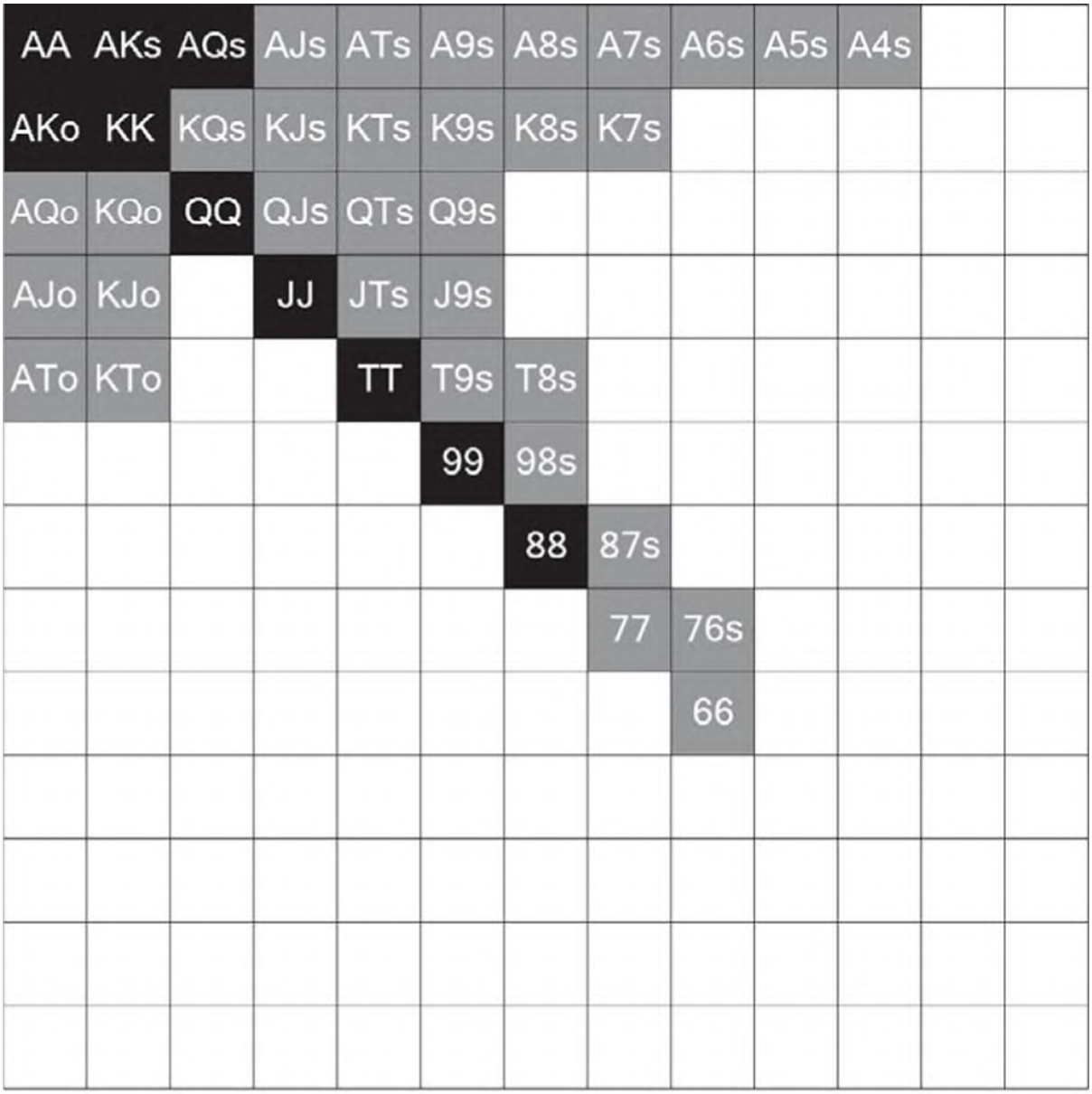
Hand Range 291: UTG 25bb (2x vs SB All-in) • Call All-in 34.5% / • Fold 65.5%



Hand Range 292: UTG 25bb (2x vs BN All-in) • Call All-in 33.9% / • Fold 66.1%



Hand Range 293: UTG 25bb (2x vs HJ All-in) • Call All-in 30.6% / • Fold 69.4%



Hand Range 294: UTG 25bb (2x vs UTG+1 All-in) • Call All-in 27.9% / • Fold 72.1%

Mid Stack Open vs Non-all-in 3-bet (25-40bb)

The following tables show the action frequencies for a mid stack open facing a non-all-in 3-bet in terms of Villain position *(Tables 83-84)* and stack depth *(Table 85)*.

Position	All-in	Call	Fold
BN	12.68%	44.50%	42.82%
CO	13.10%	45.88%	41.02%
HJ	12.77%	49.75%	37.48%
LJ	12.48%	51.00%	36.52%
UTG+2	12.90%	50.92%	36.18%
UTG+1	13.52%	49.07%	37.42%
UTG	15.15%	45.60%	39.25%
Average	13.23%	48.10%	38.67%

Table 83: Action Frequencies Versus the Blinds (IP)

Position	All-in	Call	Fold
CO	20.27%	37.10%	42.63%
HJ	20.68%	38.12%	41.20%
LJ	21.82%	37.34%	40.83%
UTG+2	22.22%	37.92%	39.87%
UTG+1	22.68%	37.29%	40.03%
UTG	25.03%	30.24%	44.73%
Average	22.84%	35.47%	41.69%

Table 84: Action Frequencies vs Other Positions (OOP)

Stack Depth	All-in	Call	Fold
IP	13.23%	48.10%	38.67%
25	16.68%	44.59%	38.73%
30	12.67%	48.11%	39.22%
40	10.34%	51.61%	38.06%
OOP	22.84%	35.47%	41.69%
25	22.97%	44.19%	32.84%
30	22.63%	39.20%	38.17%
40	22.91%	23.03%	54.06%
Total	18.99%	40.52%	40.48%

Table 85: Action Frequencies by Stack Depth

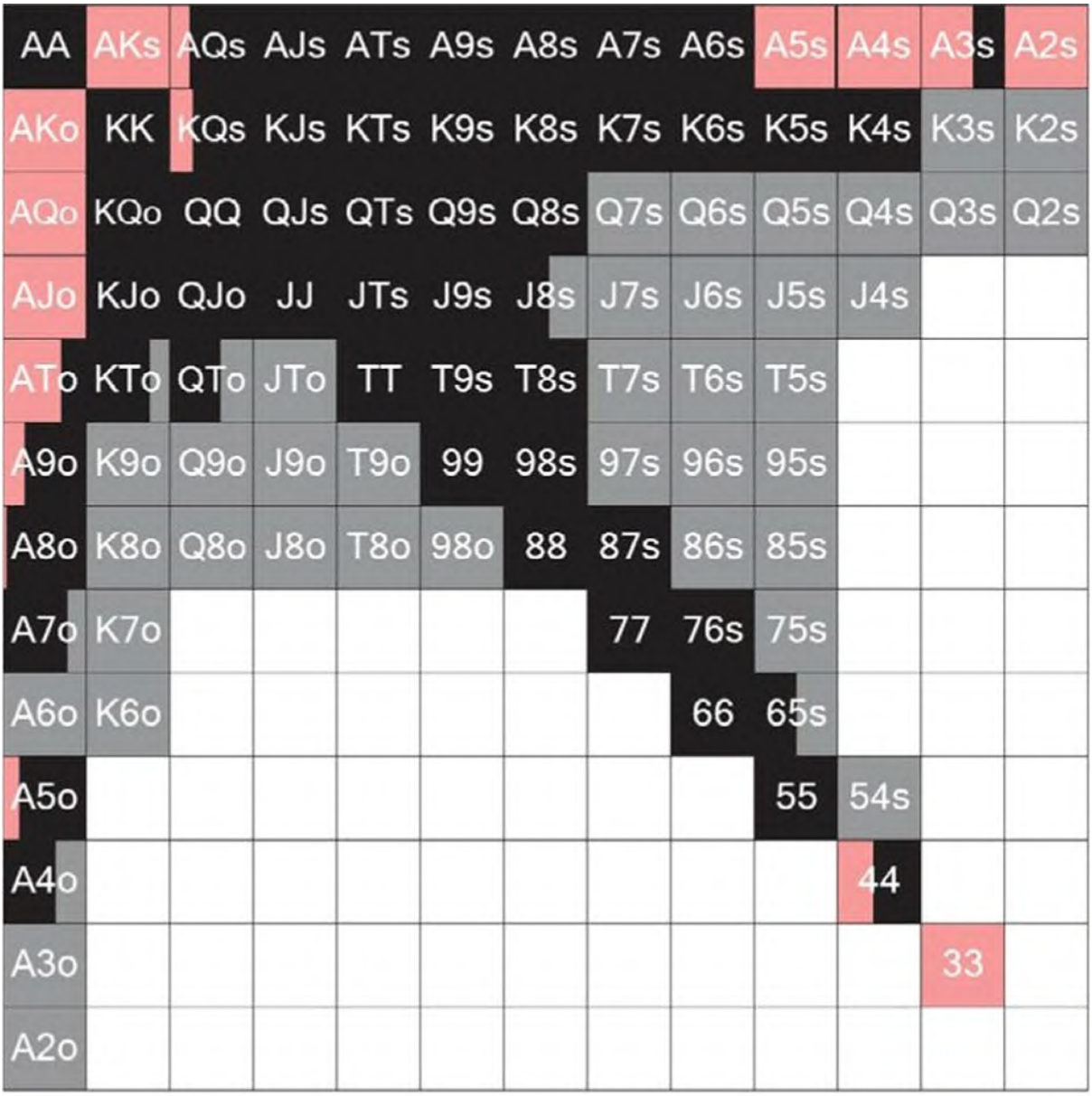
When facing a non-all-in 3-bet with 25-40bb stacks, the solver's only 4-bet-size is all-in. In this situation, there is a meaningful strategic difference when comparing being in position or out of position vs the 3-bettor.

When IP, the average fold to 3-bet is lower than when the opener is OOP. Also, the opener should be way more likely to 4-bet when OOP and prefer to call the 3-bet and play post-flop when having position on the 3-bettor.

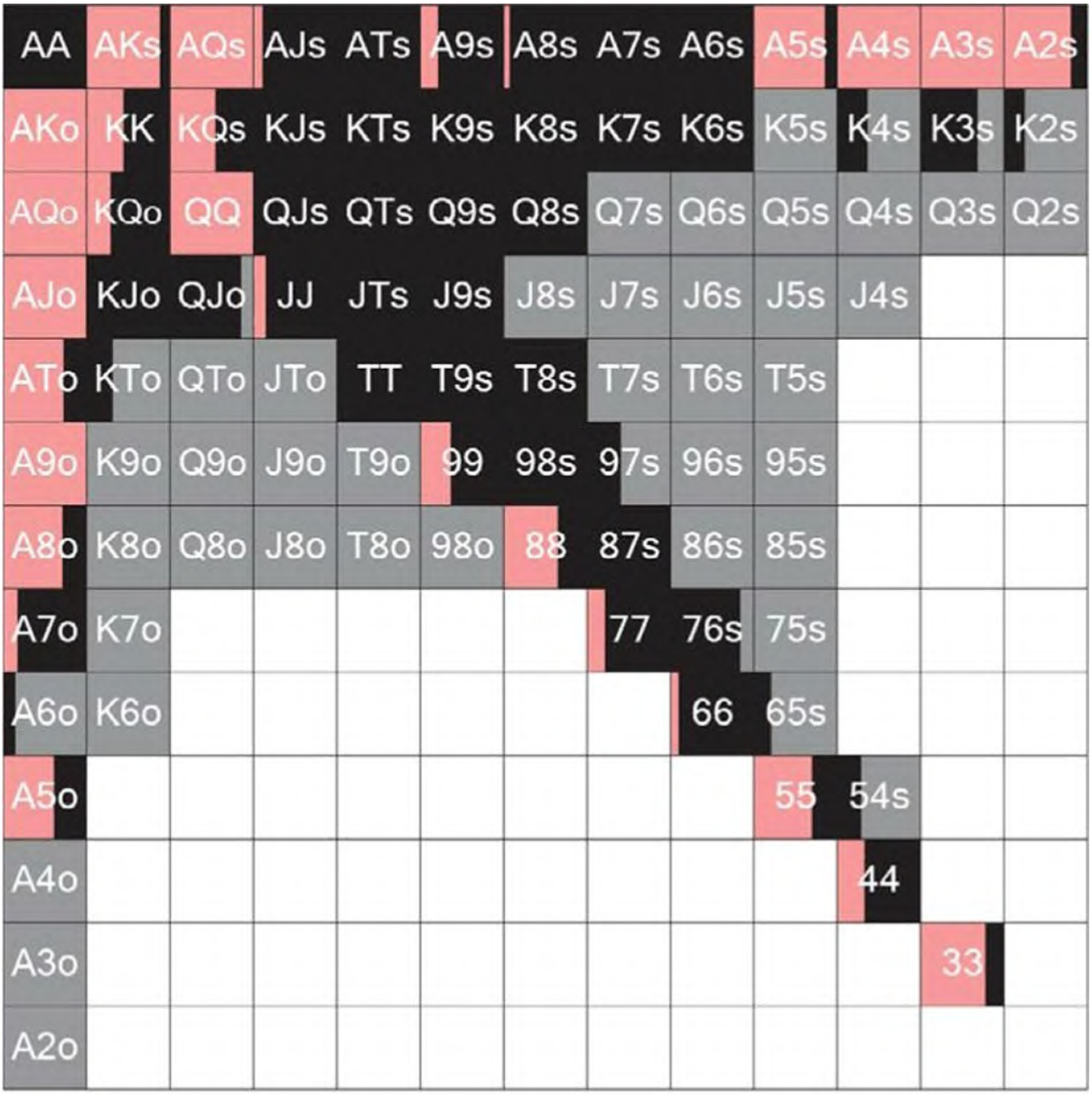
There is also a correlation between stack depth and 4-betting frequency when the opener is IP. In that case, the bigger the stack, the lower the 4-betting frequency and the more inclined the opener should be to call and take flops. Conversely, when the opener is OOP, the 4-betting frequency remains constant at ~22.84% and the calling frequency actually decreases as stacks get deeper, going from an average calling frequency of 44.19% at 25bb to 23.03% at 40bb. This is because with deeper stacks it becomes more difficult for the OOP player to realize equity post-flop.

In short, when facing a 3-bet and having position, the opener should 4-bet more with short stacks and call more with deep stacks, and when the opener is OOP, they should fold more to 3-bets when having a deep stack and call more when having a short stack.

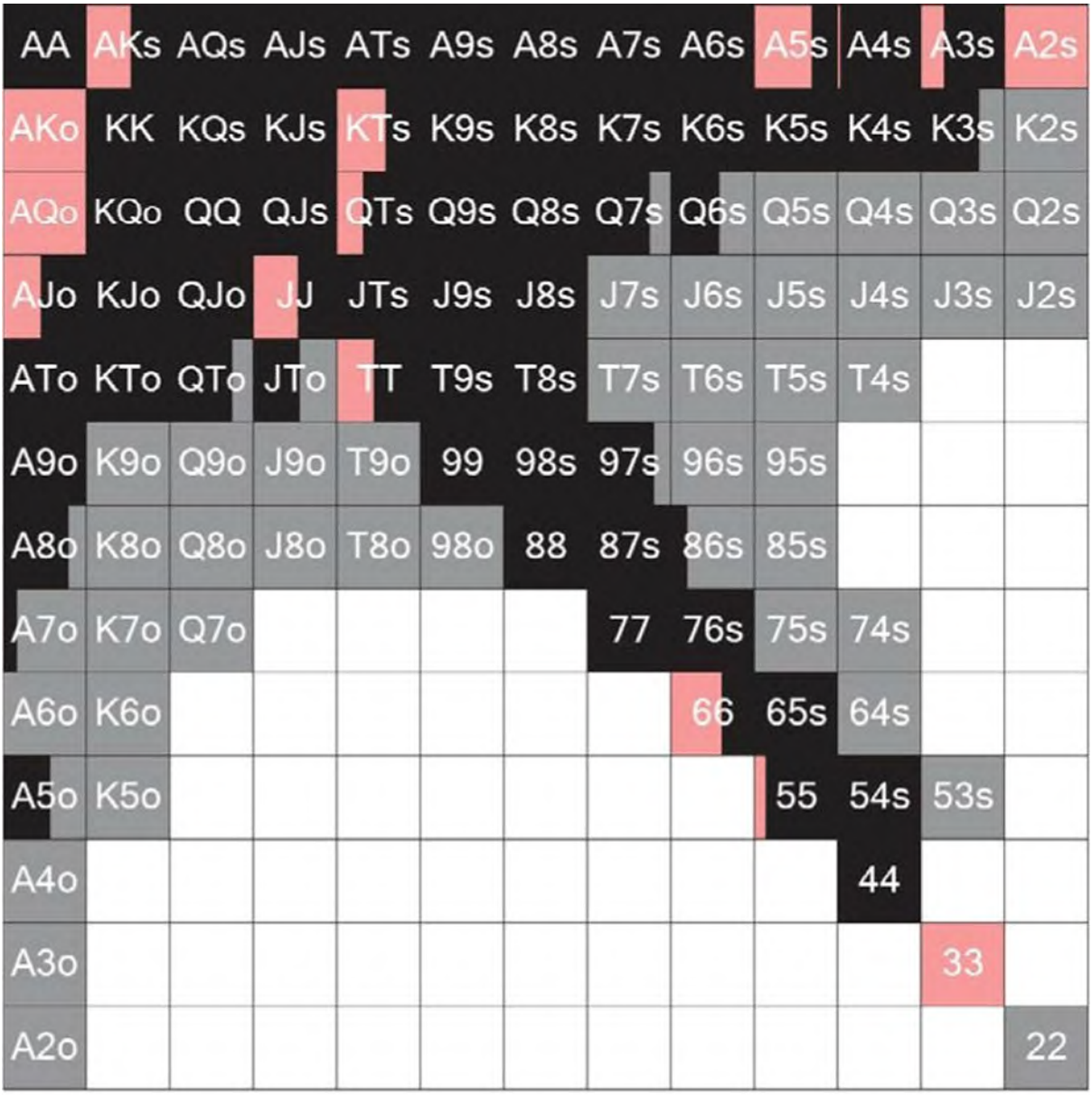
The types of hands that tend to play better as 4-bets change depending on the positions involved. In general, the solver likes 4-betting all-in with hands that have good equity vs calling ranges but not great playability, such as mid-small pocket pairs, big offsuit Ax and small suited Ax. The hands that tend to do better as calls are AA, KK, suited connectors, suited broadways, and big suited Ax. The frequency with which these hands get 4-bet or called depends on the stack depth and the opener's relative position against the 3-bettor. For more details, diligently analyze the following charts *(Hand Ranges 295-322)*.



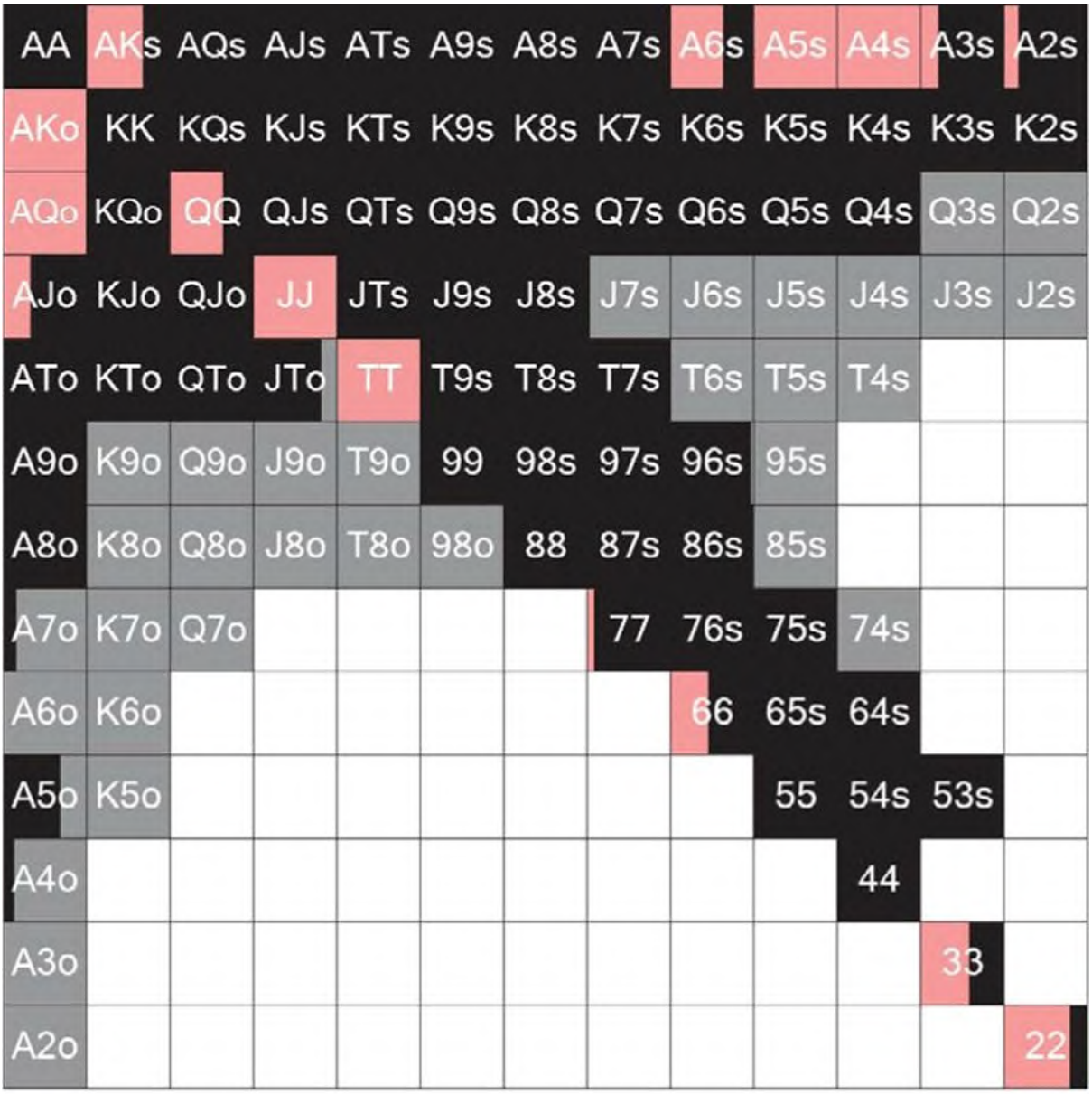
Hand Range 295: BN 25bb (2x vs BB 3-bet) • All-in 12.4% / • Call 45.4% / • Fold 42.2%



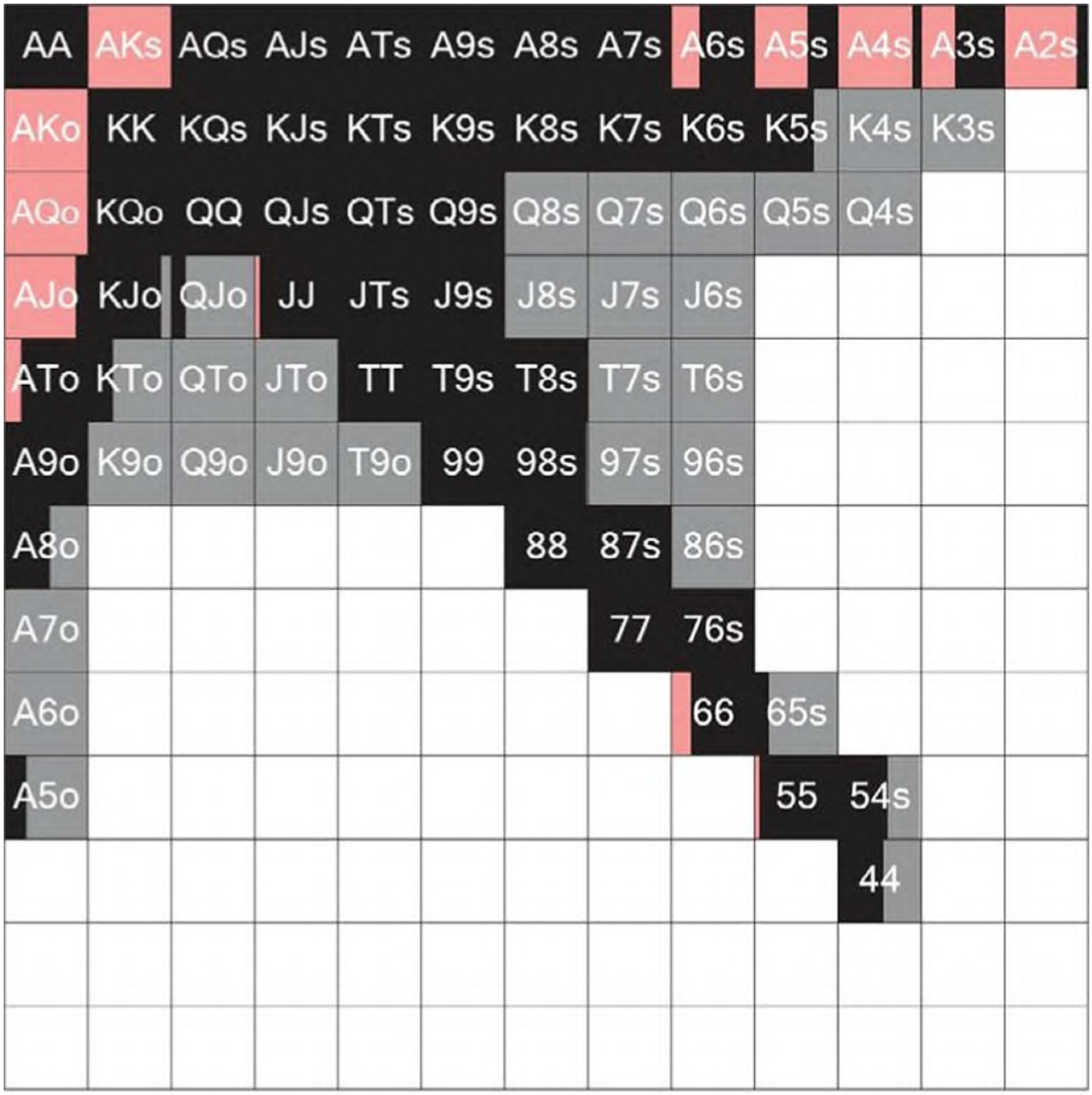
Hand Range 296: BN 25bb (2x vs SB 3-bet) • All-in 21.1% / • Call 33.1% / • Fold 45.8%



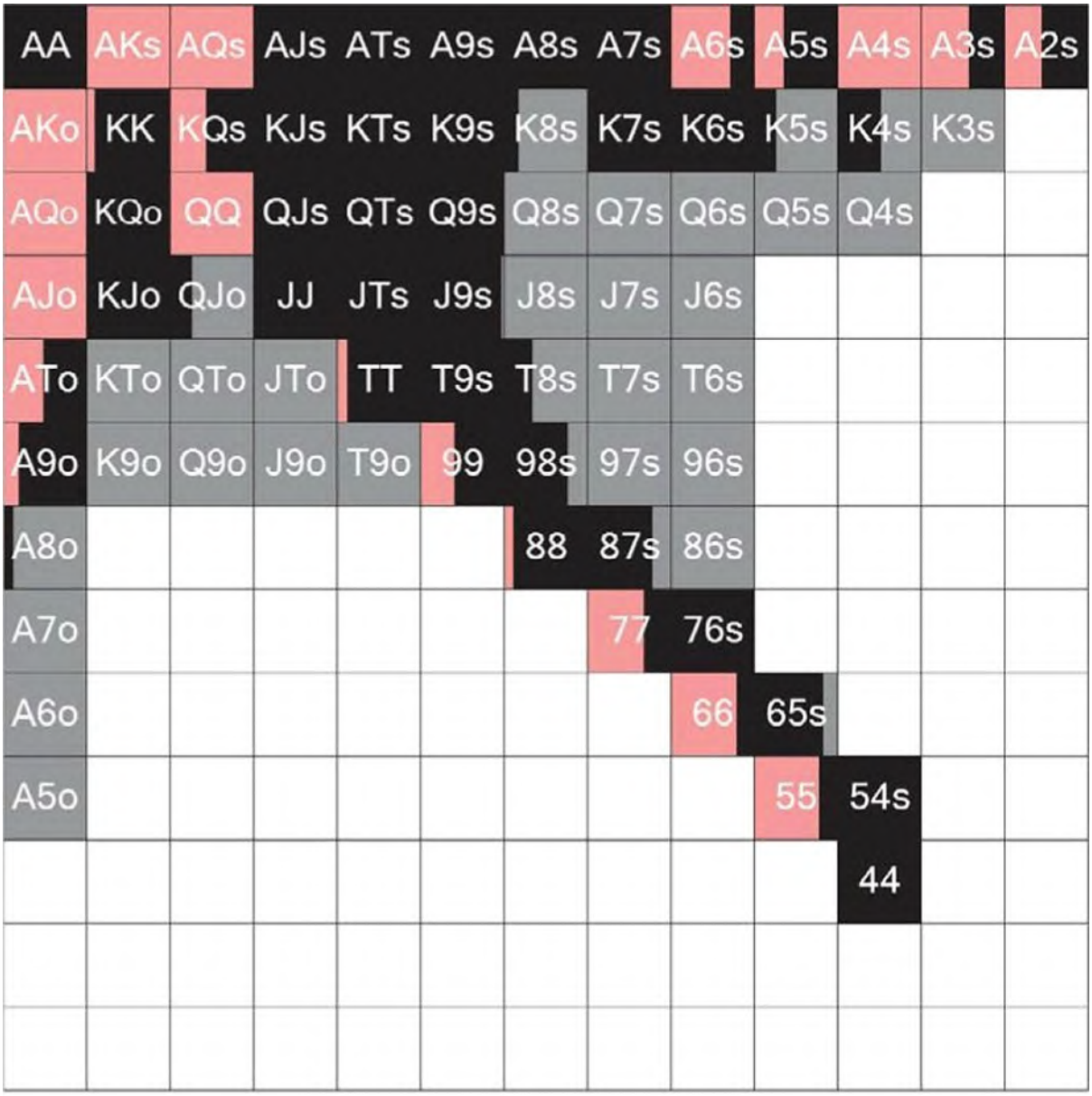
Hand Range 297: BN 40bb (2.3x vs BB 3.5x 3-bet) • All-in 8.8% / • Call 45.4% / • Fold 45.7%



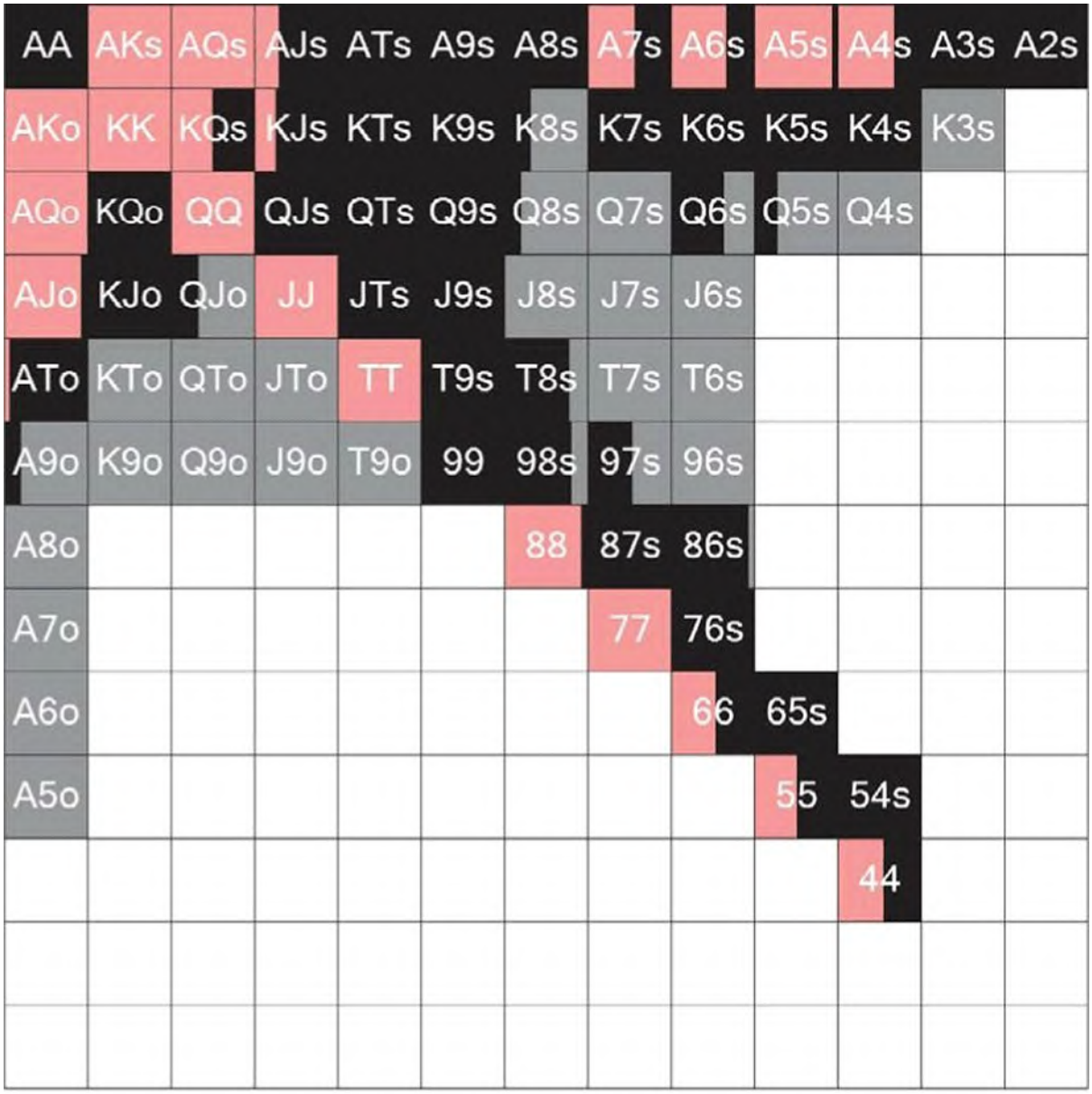
Hand Range 298: BN 40bb (2.3x vs SB 3.3x 3-bet) • All-in 10.4% / • Call 52.1% / • Fold 37.5%



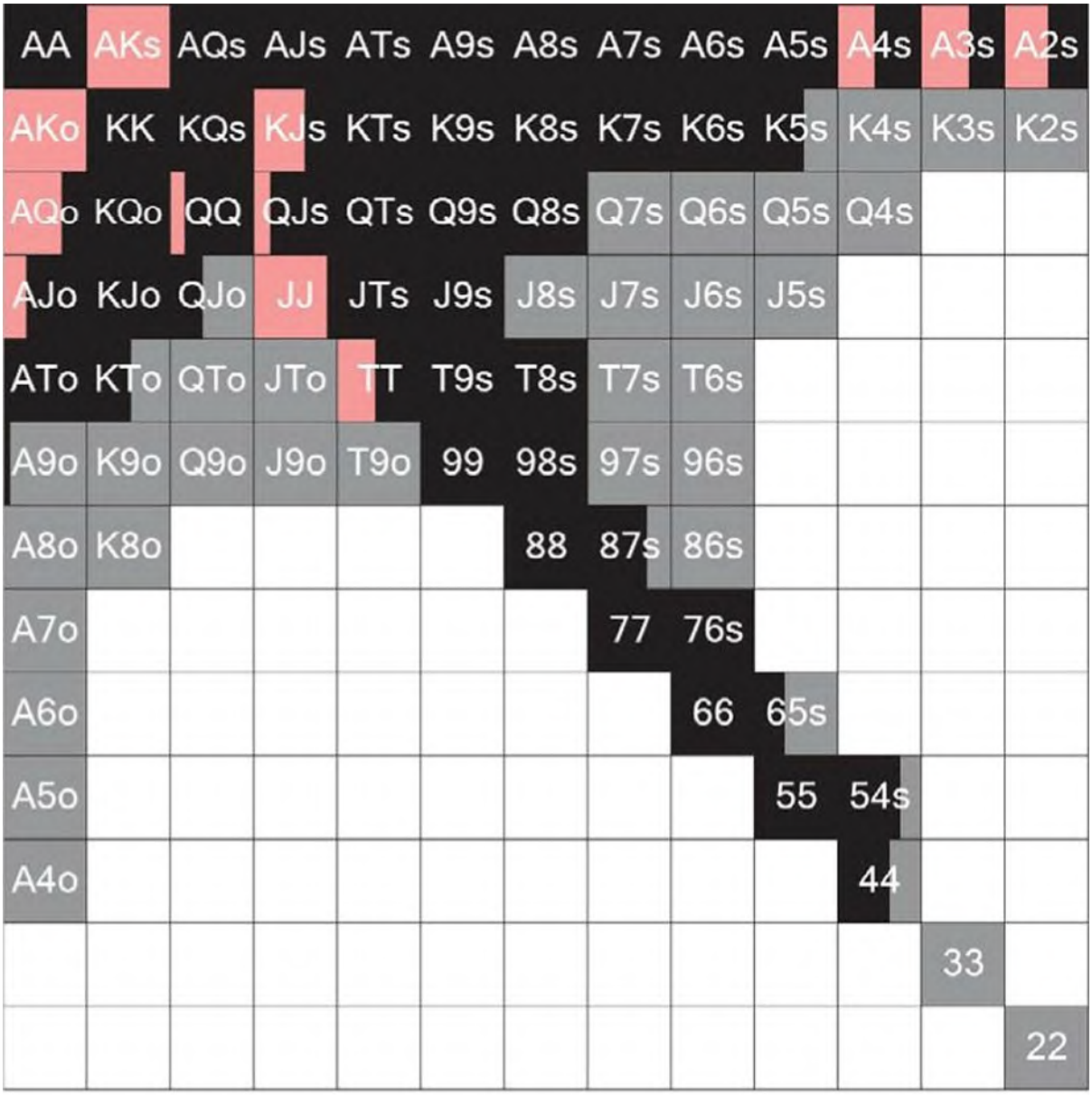
Hand Range 299: CO 25bb (2x vs BB 3.25x 3-bet) • All-in 12.2% / • Call 49.6% / • Fold 38.2%



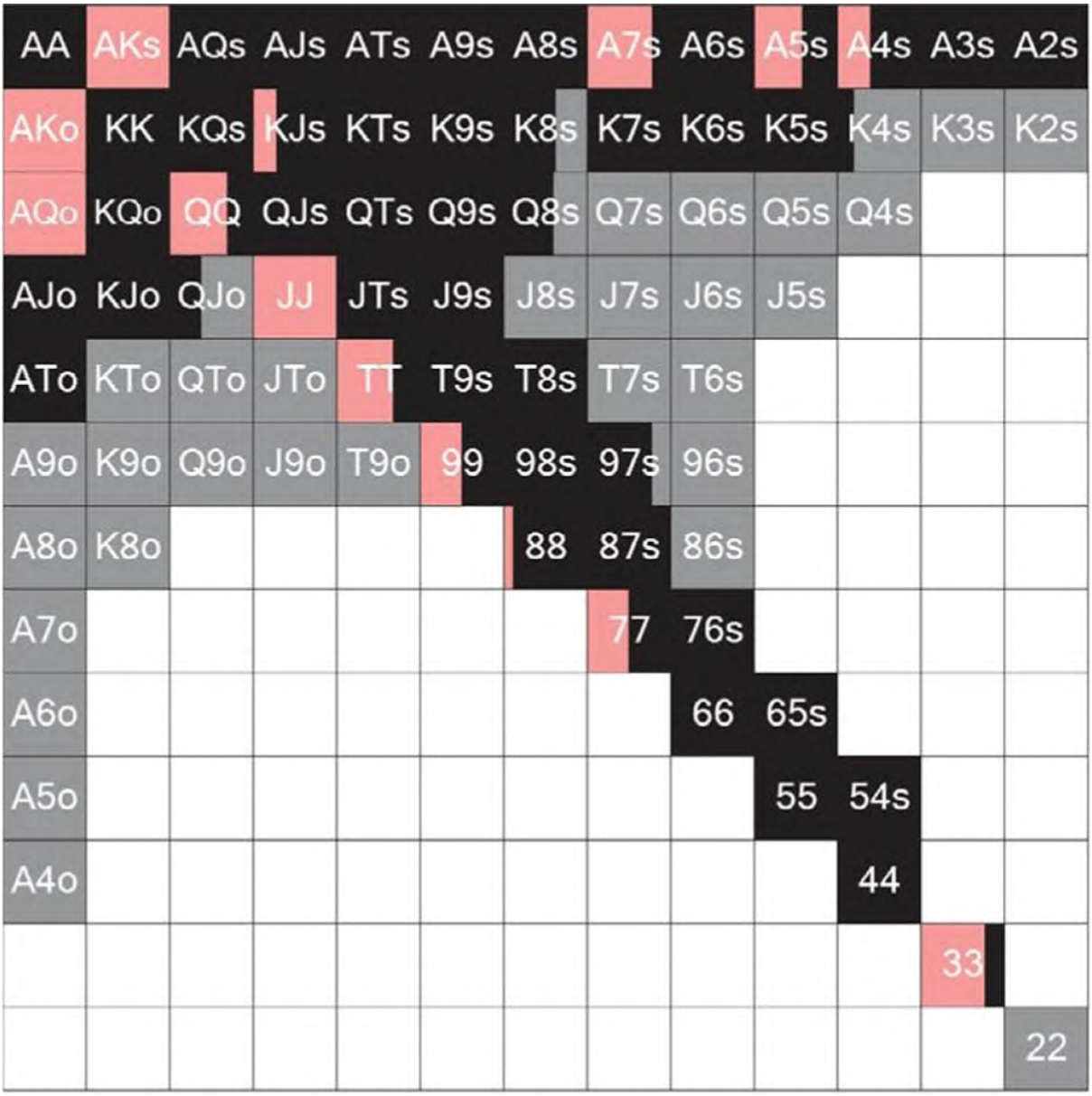
Hand Range 300: CO 25bb (2x vs SB 3x 3-bet) • All-in 19.7% / • Call 39.5% / • Fold 40.8%



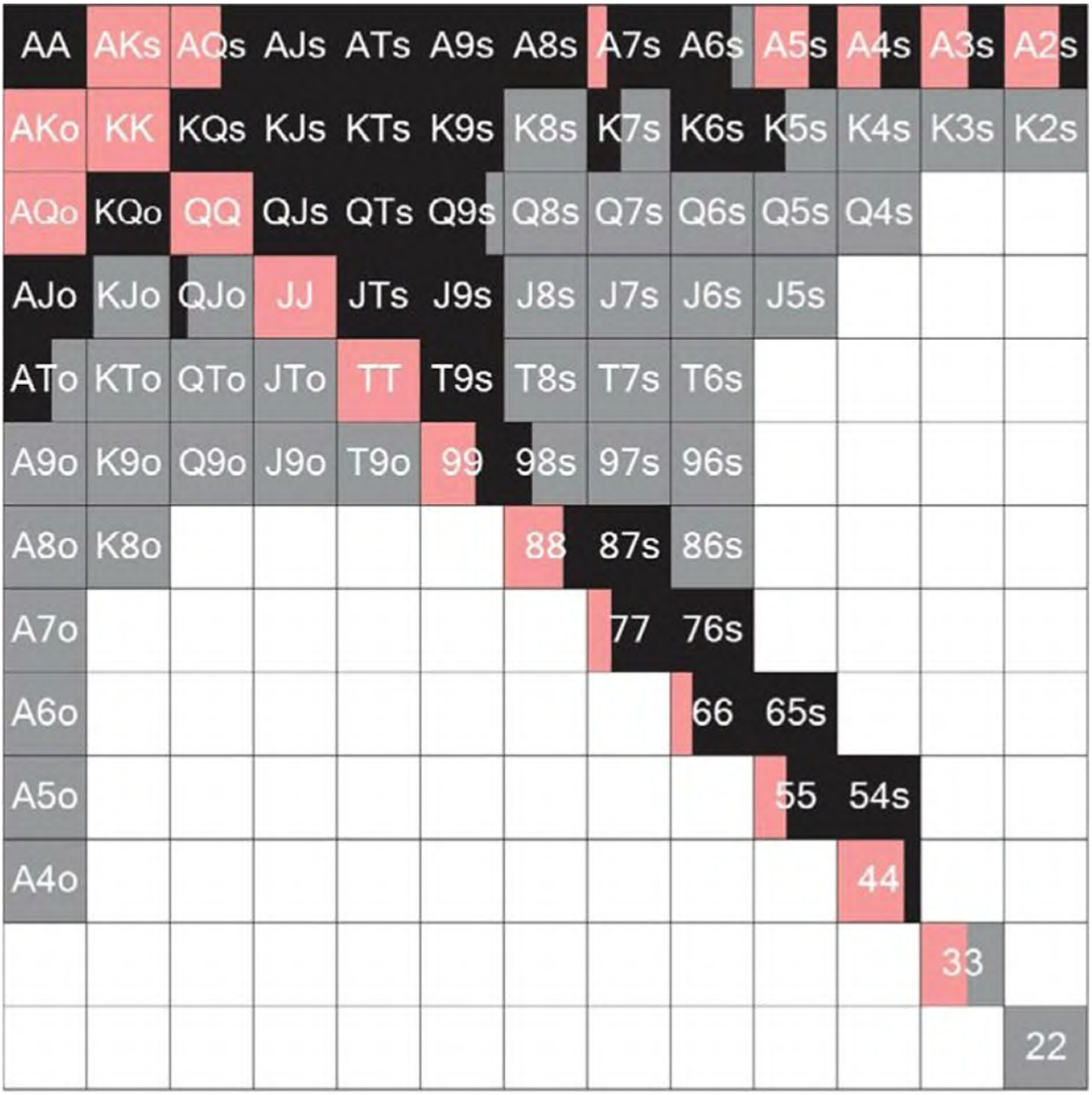
Hand Range 301: CO 25bb (2x vs BN 2.75x 3-bet) • All-in 22.9% / • Call 38.3% / • Fold 38.8%



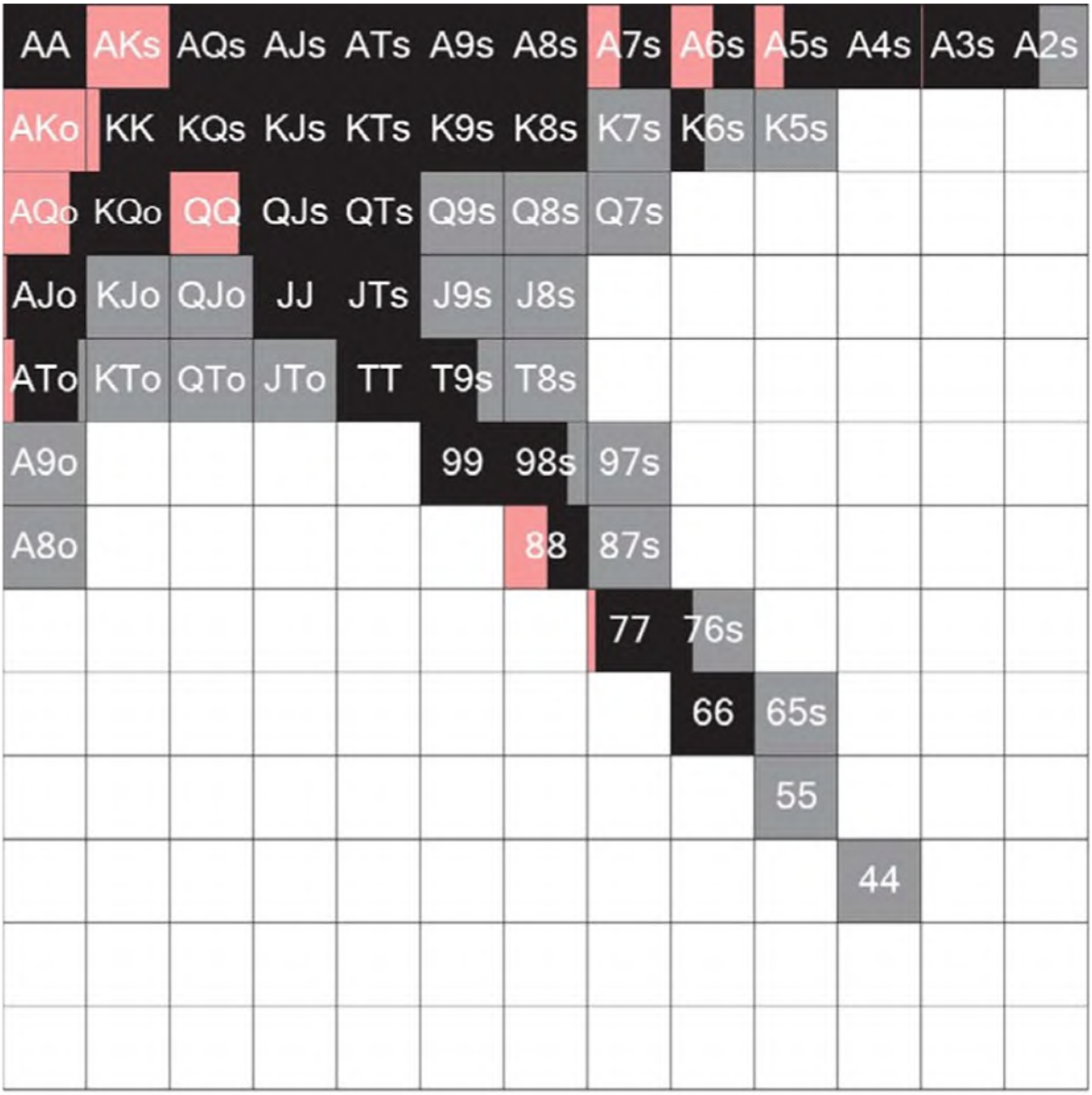
Hand Range 302: CO 40bb vs BB 3.5x 3-bet • All-in 9.6% / • Call 46.8% / • Fold 43.6%



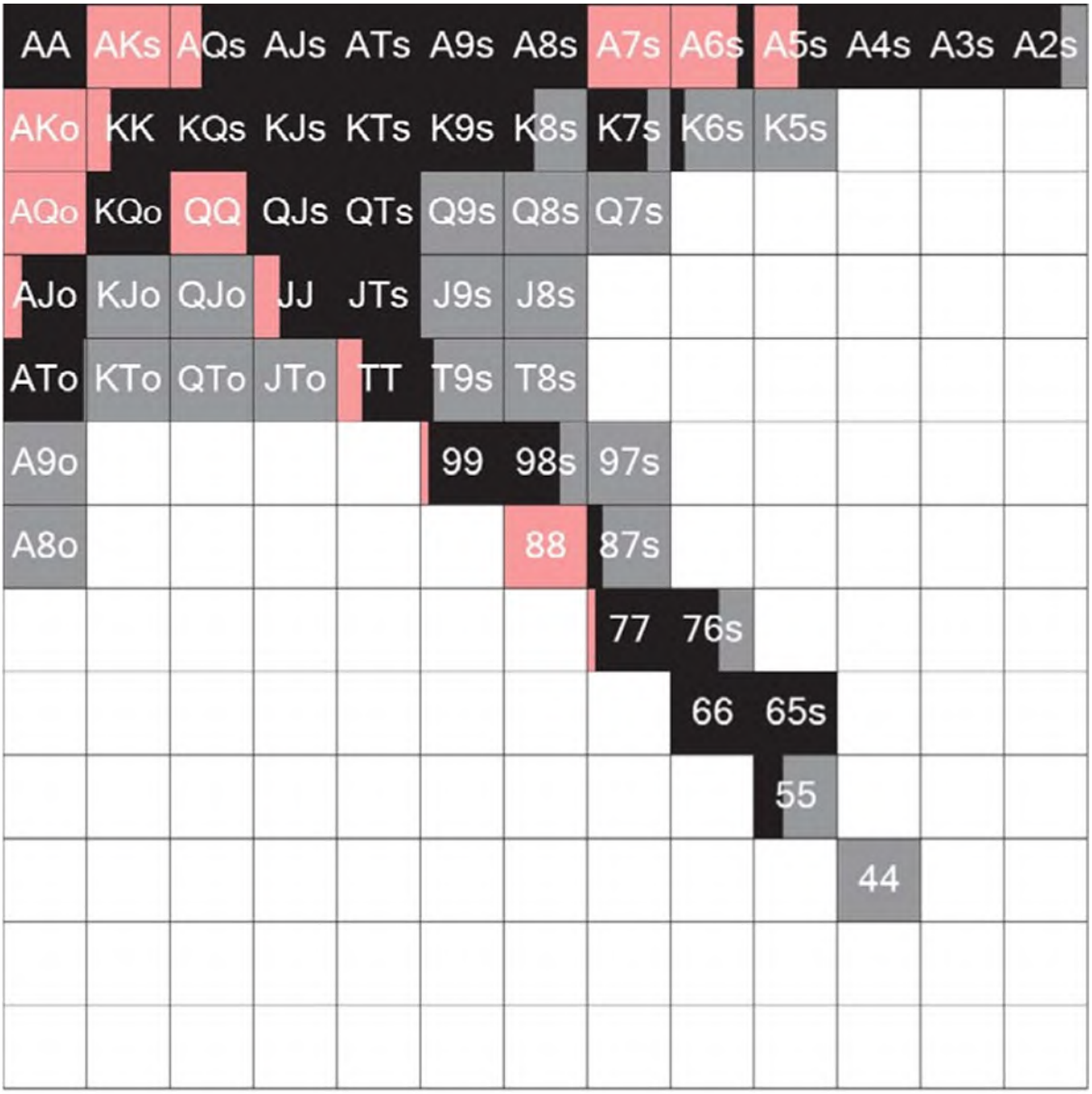
Hand Range 303: CO 40bb vs SB 3.3x 3-bet • All-in 12.7% / • Call 45.2% / • Fold 42.1%



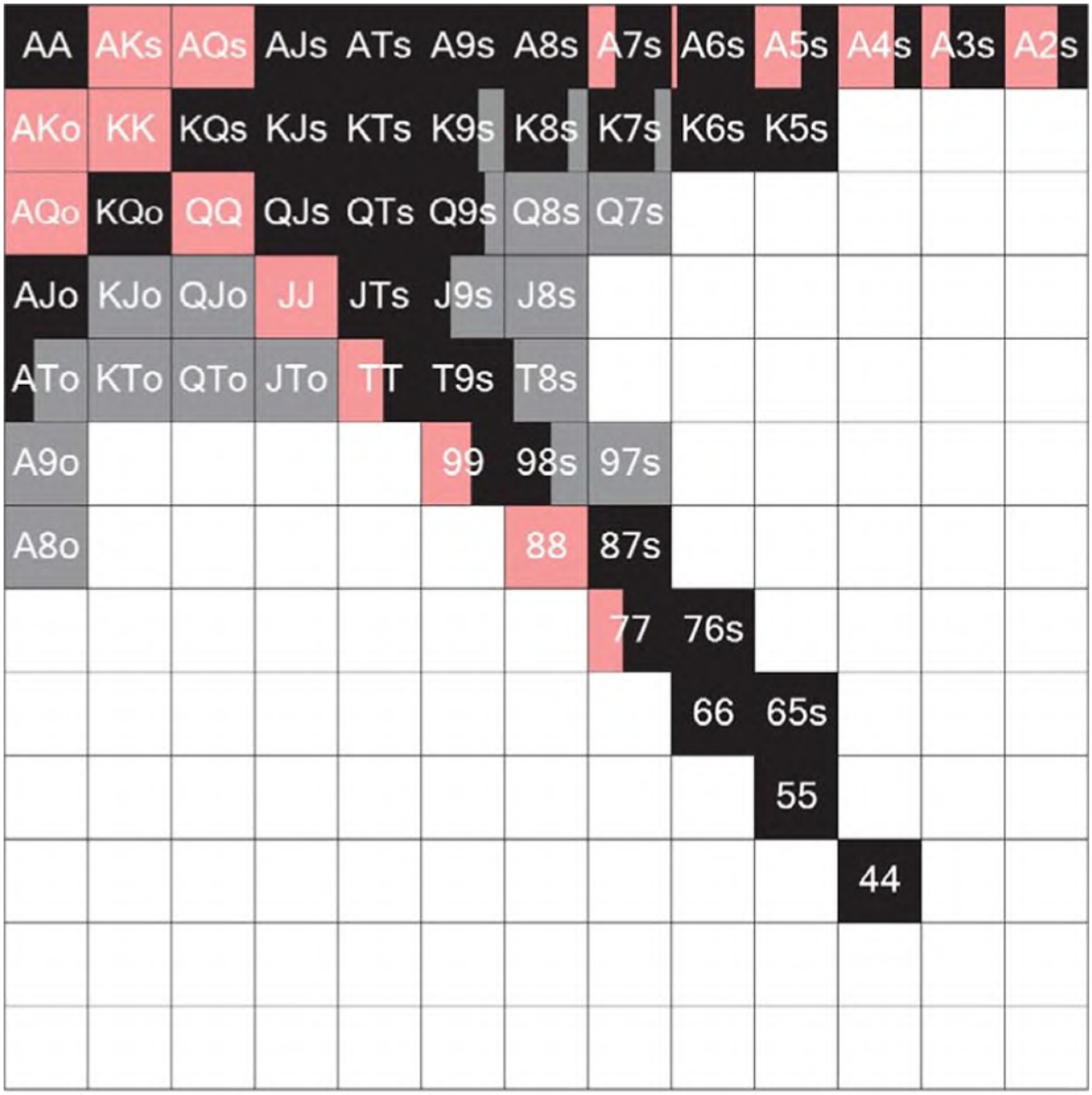
Hand Range 304: CO 40bb vs BN 3.25x 3-bet • All-in 18% / • Call 30.9% / • Fold 51%



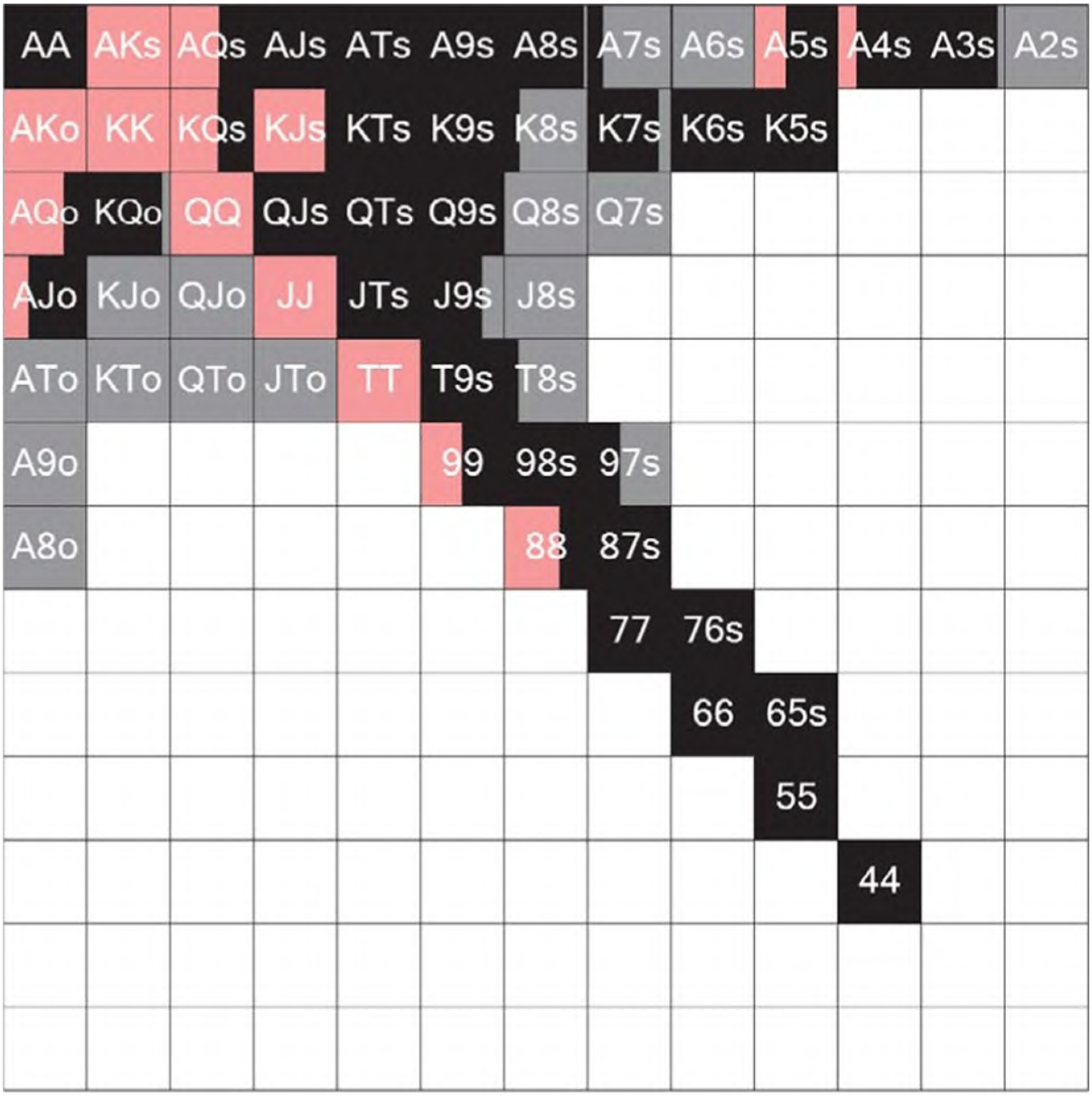
Hand Range 305: LJ 25bb (2x vs BB 3.25x 3-bet) • All-in 13.2% / • Call 49% / • Fold 37.8%



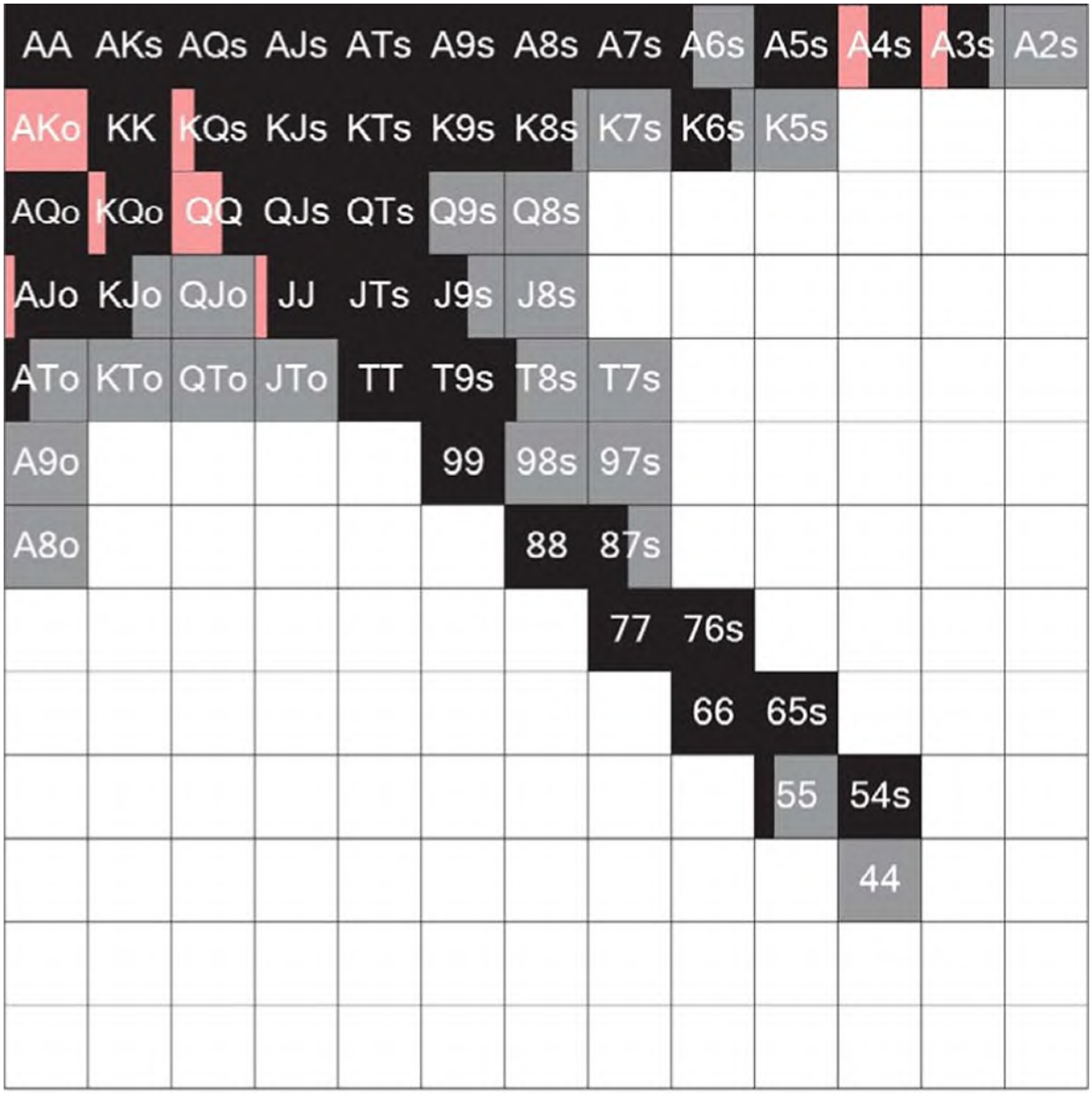
Hand Range 306: LJ 25bb (2x vs SB 3x 3-bet) • All-in 18.6% / • Call 44.6% / • Fold 36.8%



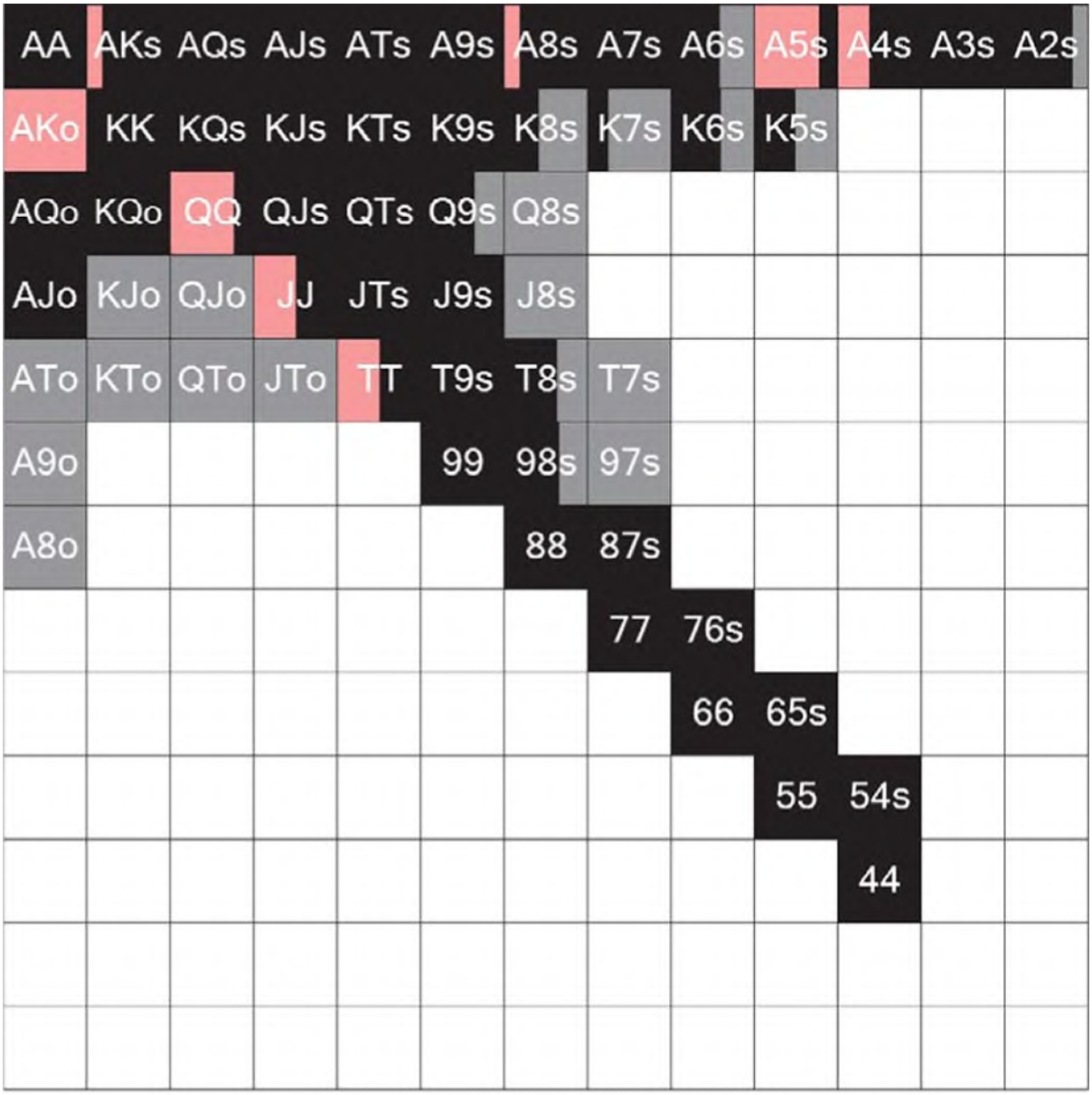
Hand Range 307: LJ 25bb (2x vs BN 2.75x 3-bet) • All-in 23.7% / • Call 44.7% / • Fold 31.7%



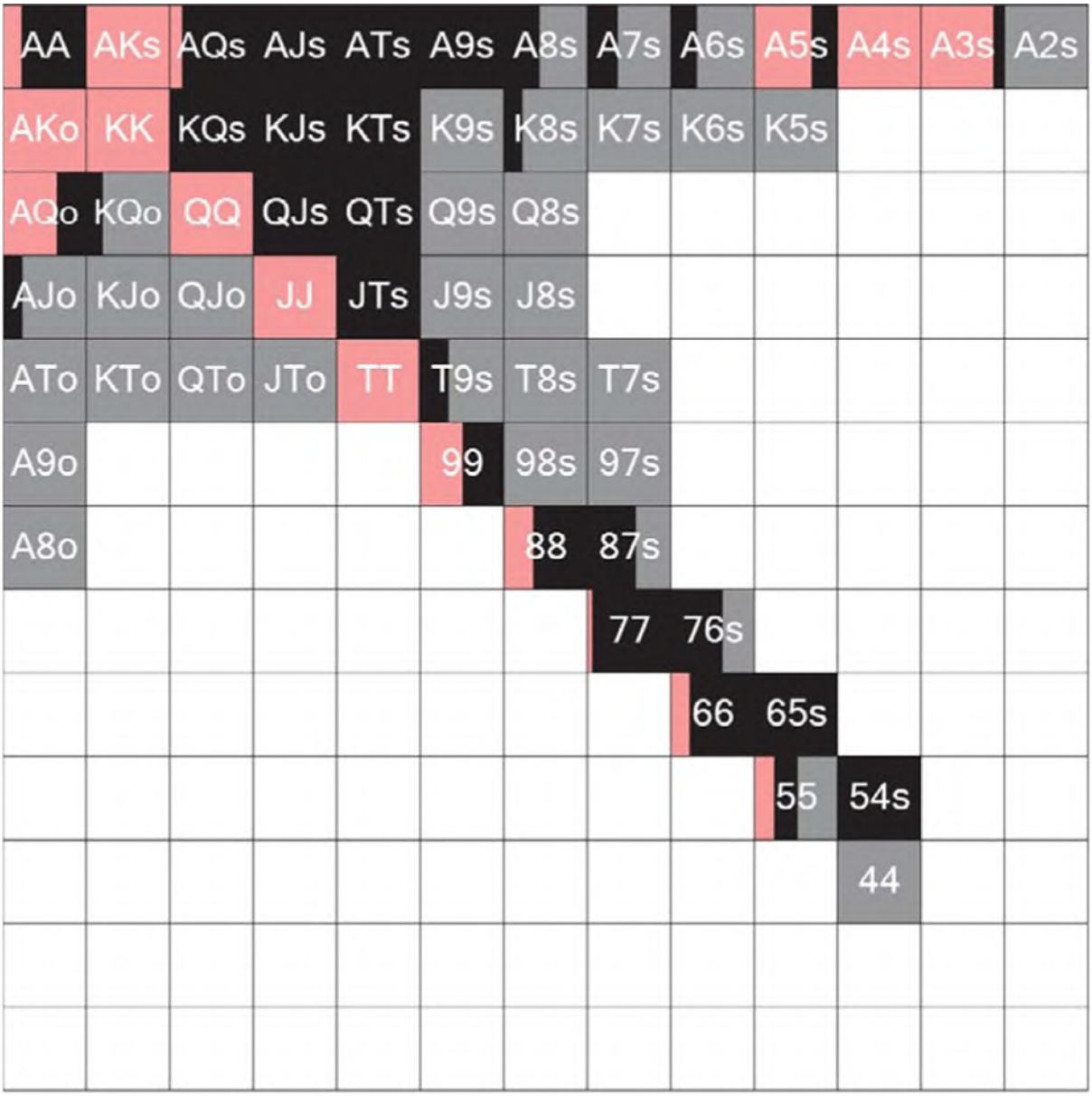
Hand Range 308: LJ 25bb (2x vs HJ 2.75x 3-bet) • All-in 21.8% / • Call 42.7% / • Fold 35.5%



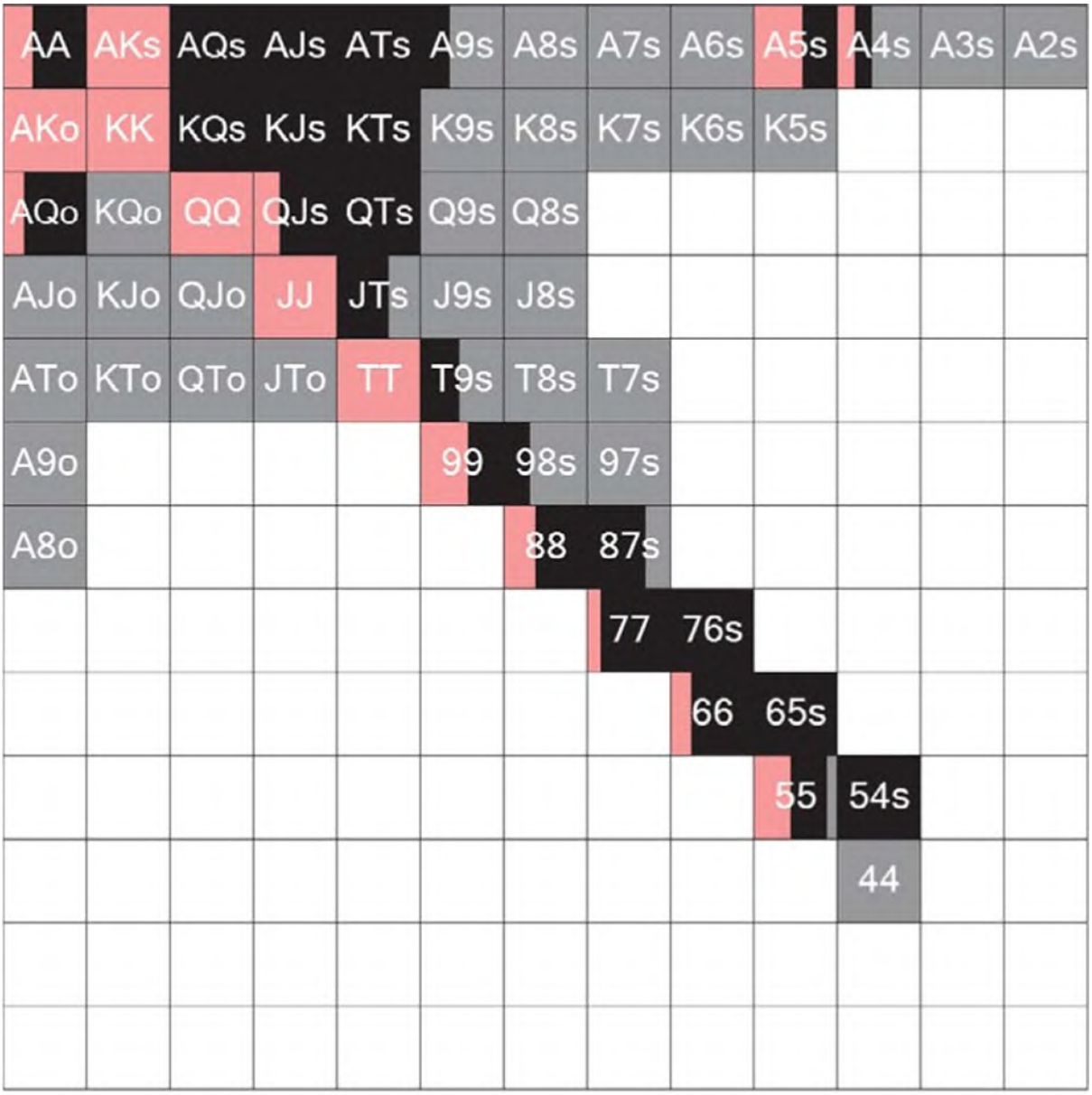
Hand Range 309: LJ 40bb vs BB 3.5x 3-bet • All-in 7.8% / • Call 56.2% / • Fold 36%



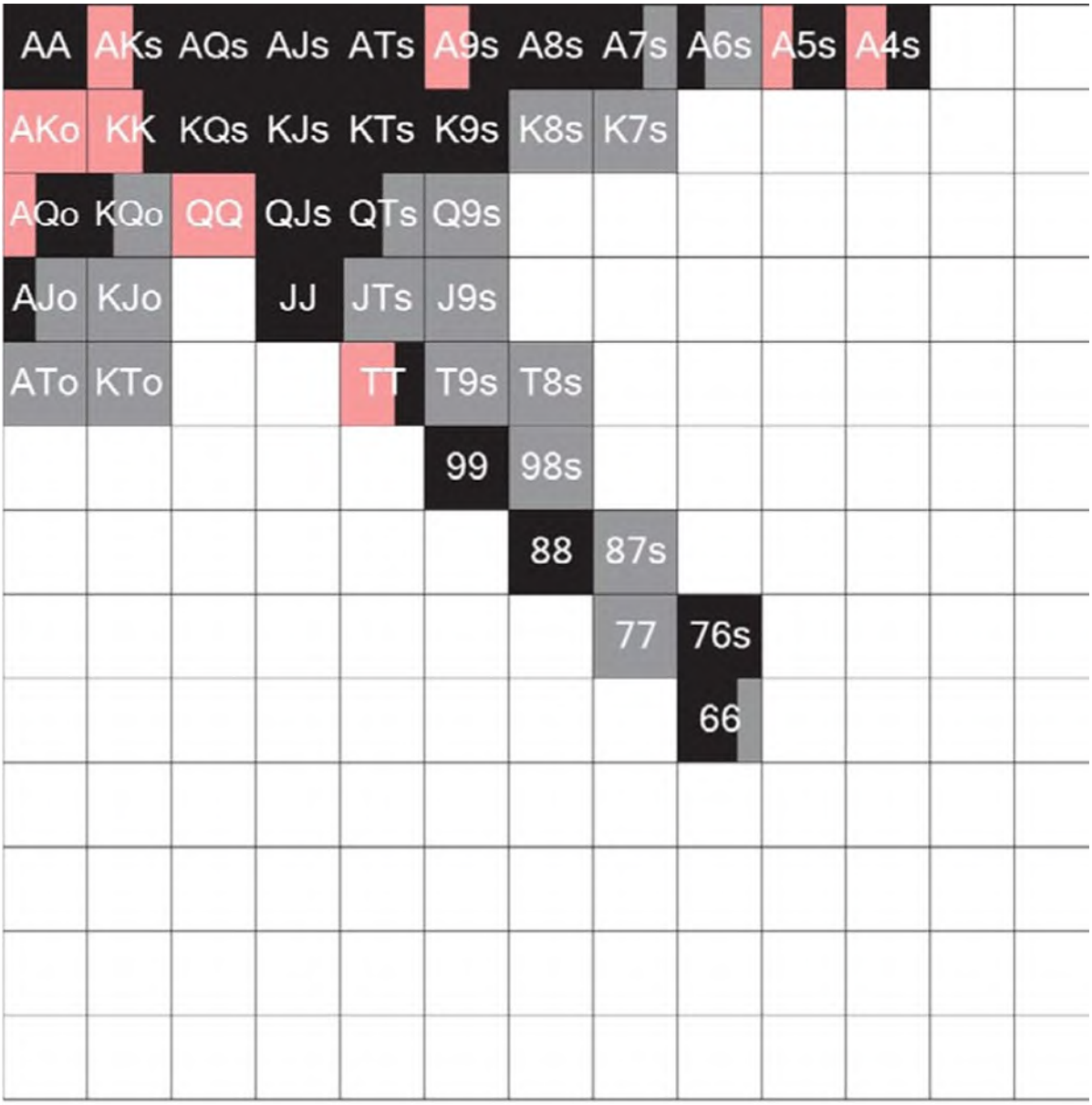
Hand Range 310: LJ 40bb vs SB 3.3x 3-bet • All-in 9.2% / • Call 58.7% / • Fold 32.1%



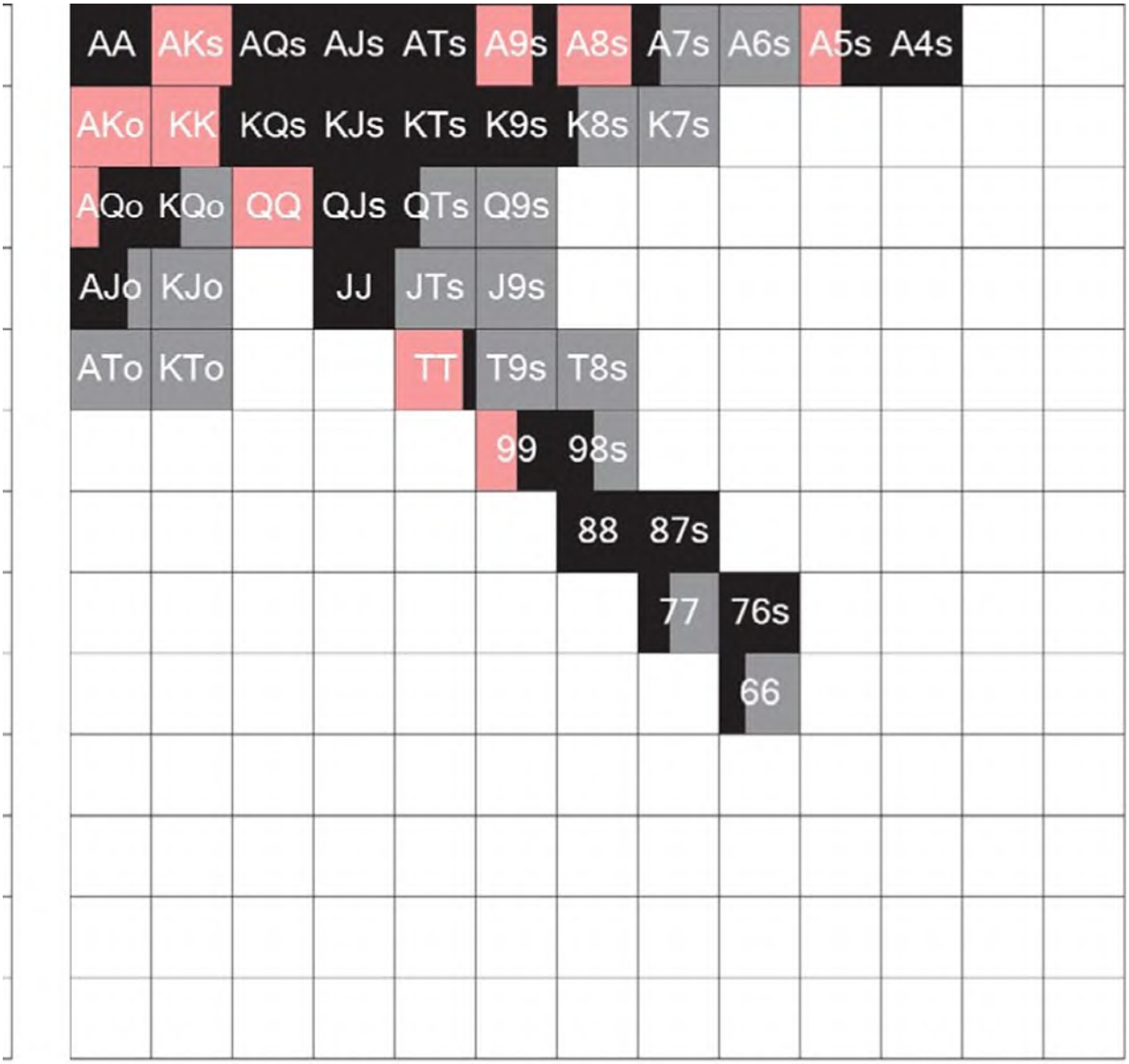
Hand Range 311: LJ 40bb vs BN 3.25x 3-bet • All-in 21.8% / • Call 27.2% / • Fold 51%



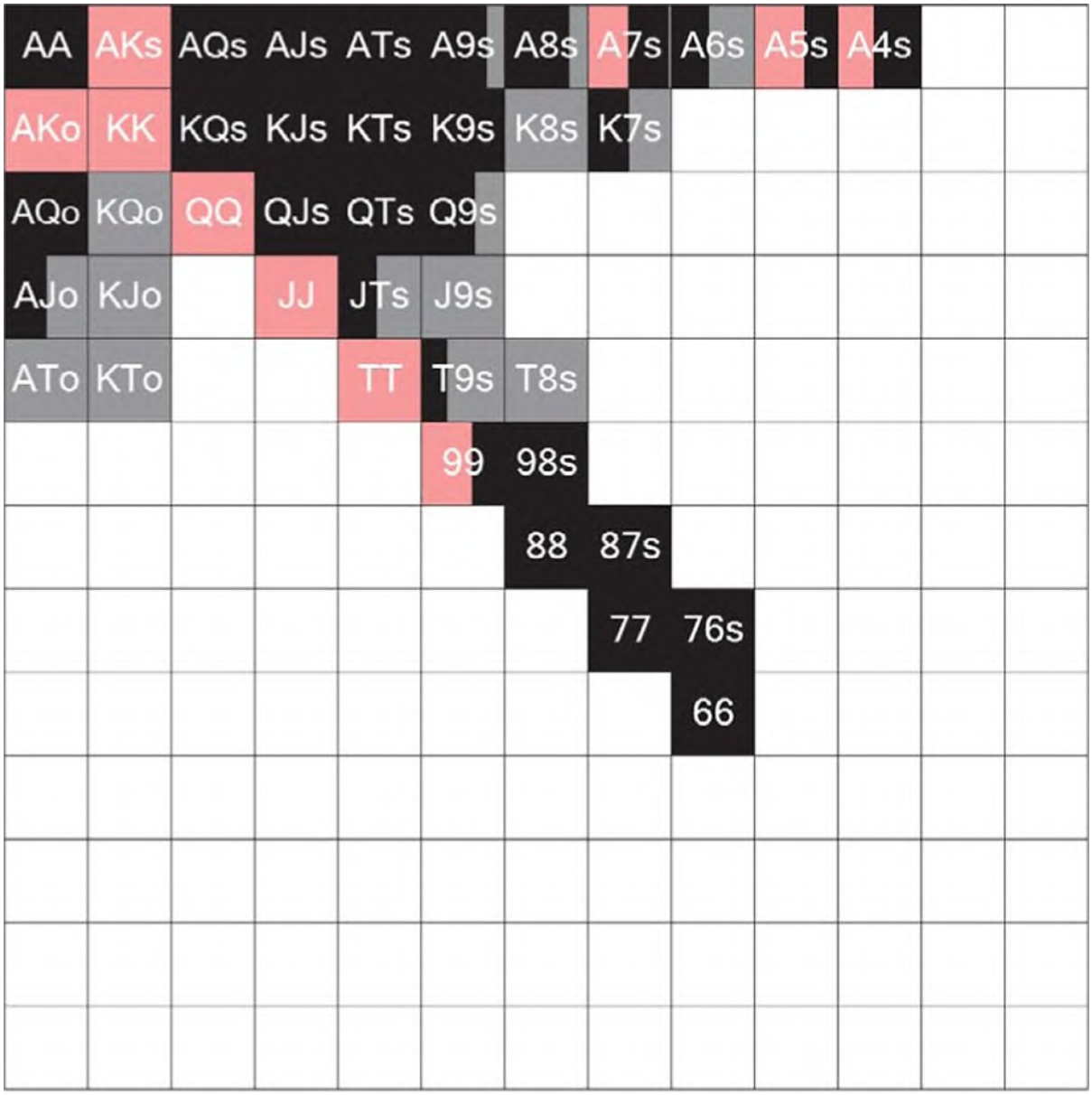
Hand Range 312: LJ 40bb vs HJ 3.25x 3-bet • All-in 19.3% / • Call 24.7% / • Fold 56%



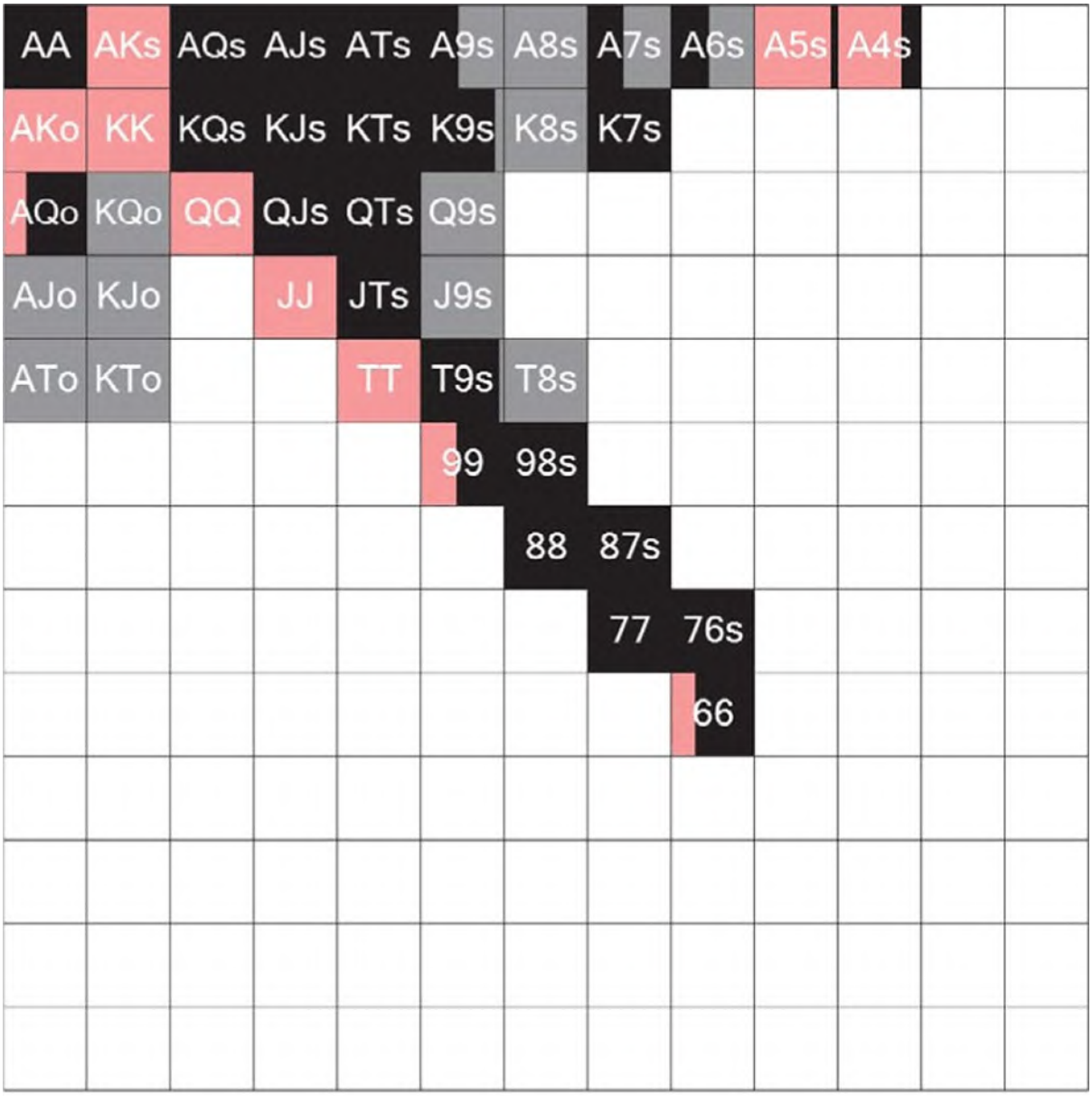
Hand Range 313: UTG 25bb (2x vs BB 3.25x 3-bet) • All-in 17.2% / • Call 44.5% / • Fold 38.3%



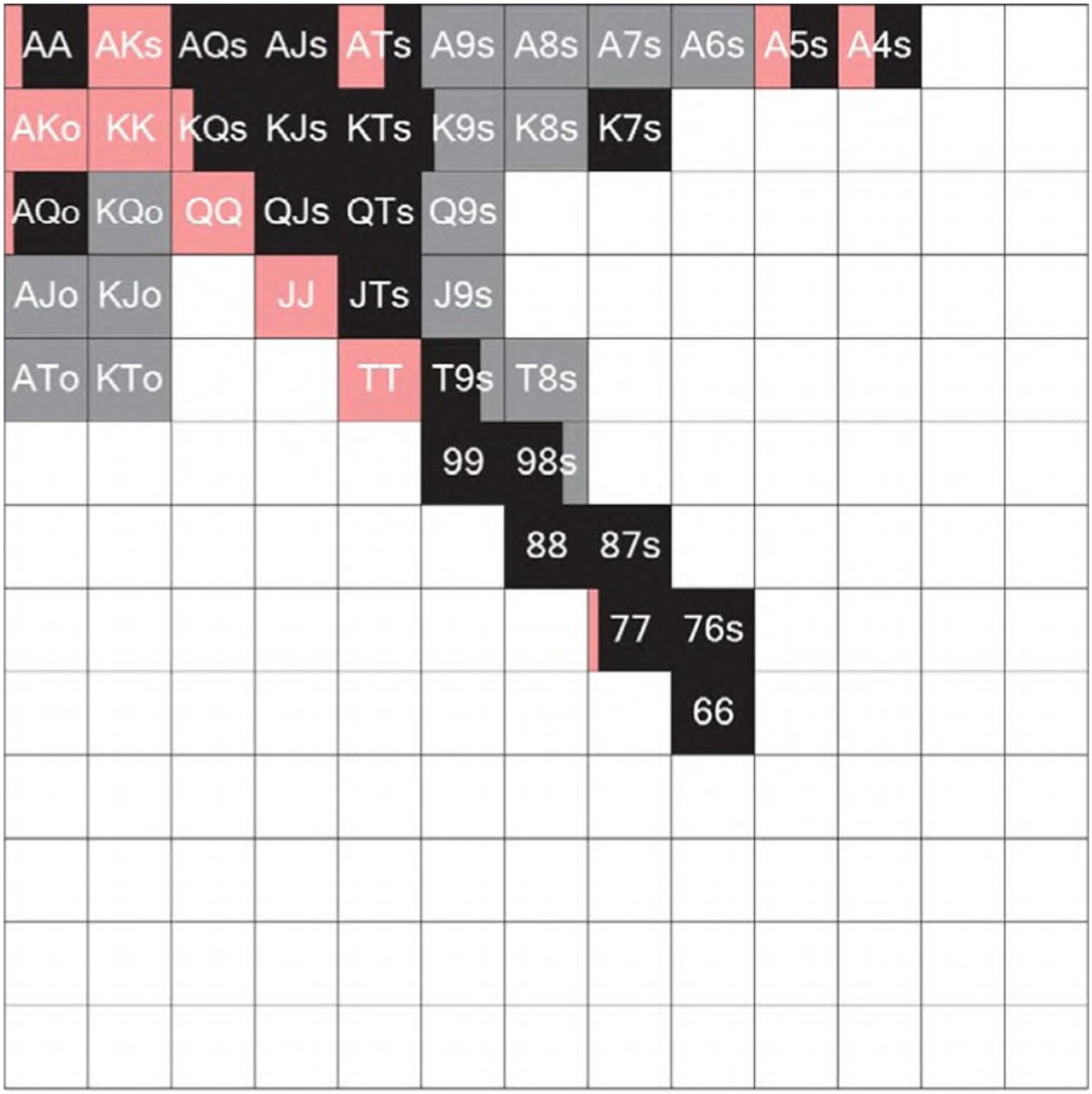
Hand Range 314: UTG 25bb (2x vs SB 3x 3-bet) • All-in 21.5% / • Call 42.2% / • Fold 36.3%



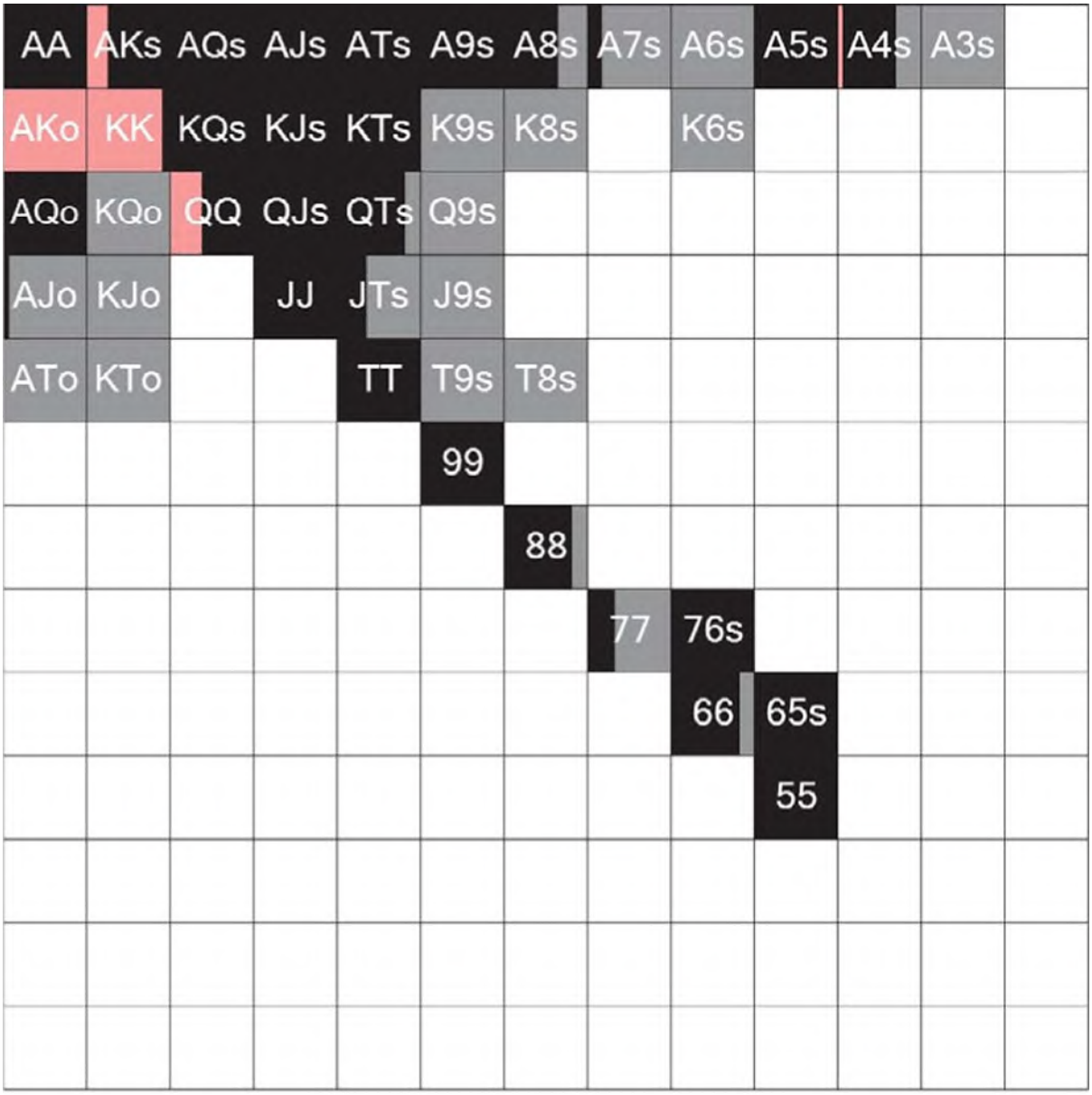
Hand Range 315: UTG 25bb (2x vs BN 2.75x 3-bet) • All-in 22.4% / • Call 47.4% / • Fold 30.3%



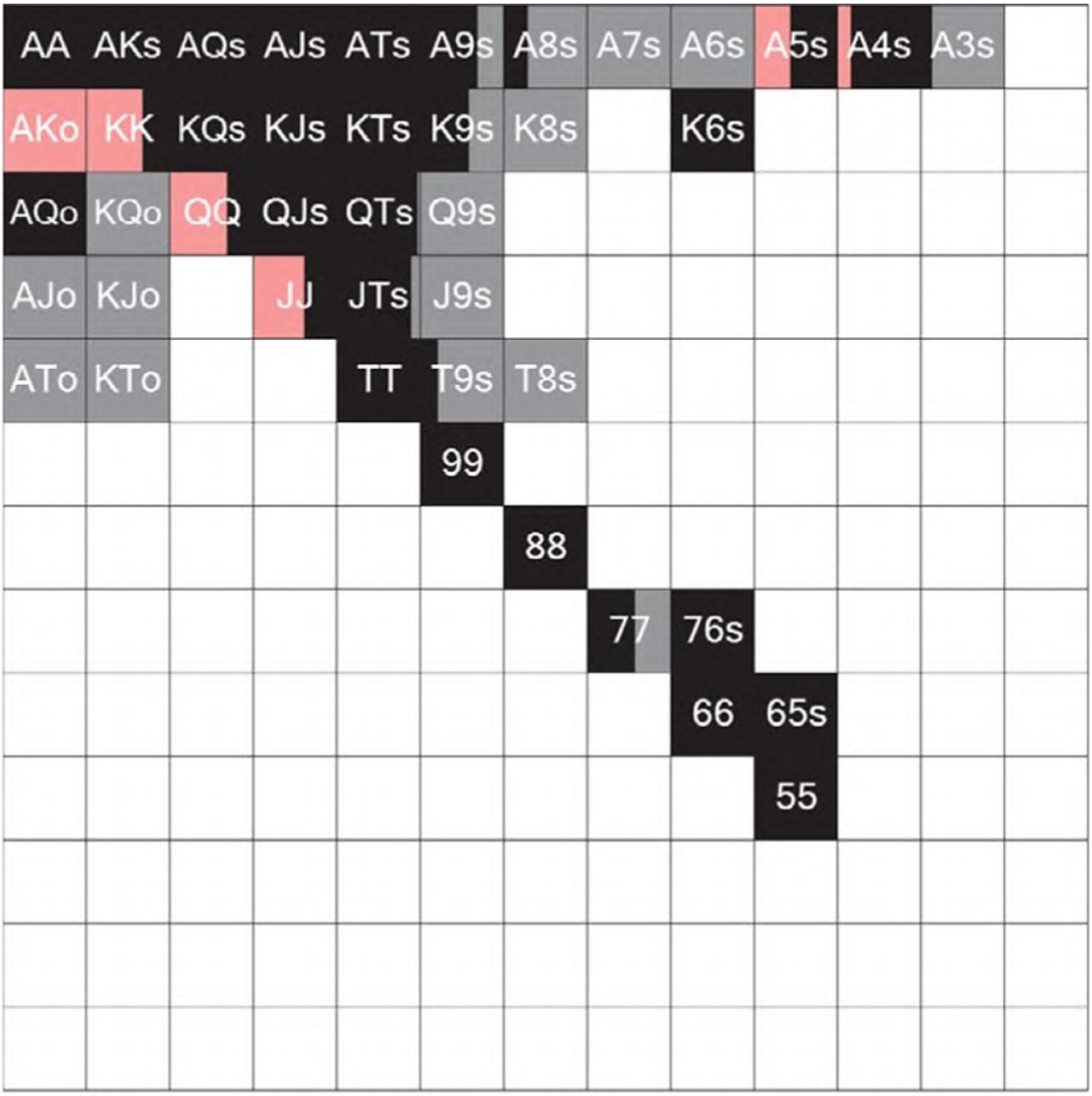
Hand Range 316: UTG 25bb (2x vs HJ 2.75x 3-bet) • All-in 24.4% / • Call 40.5% / • Fold 35.1%



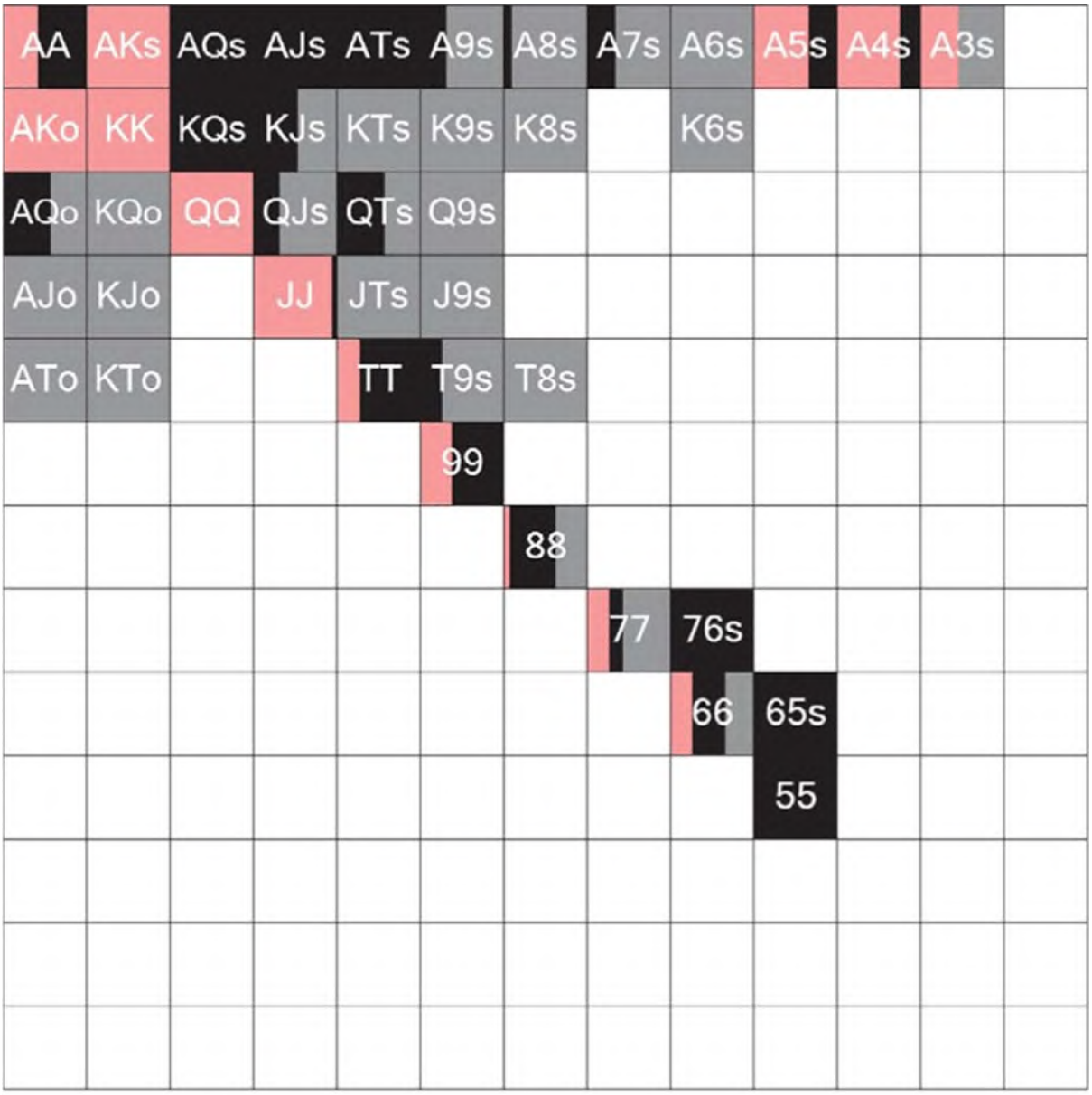
Hand Range 317: UTG 25bb (2x vs UTG+1 2.75x 3-bet) • All-in 22.5% / • Call 37.8% / • Fold 39.7%



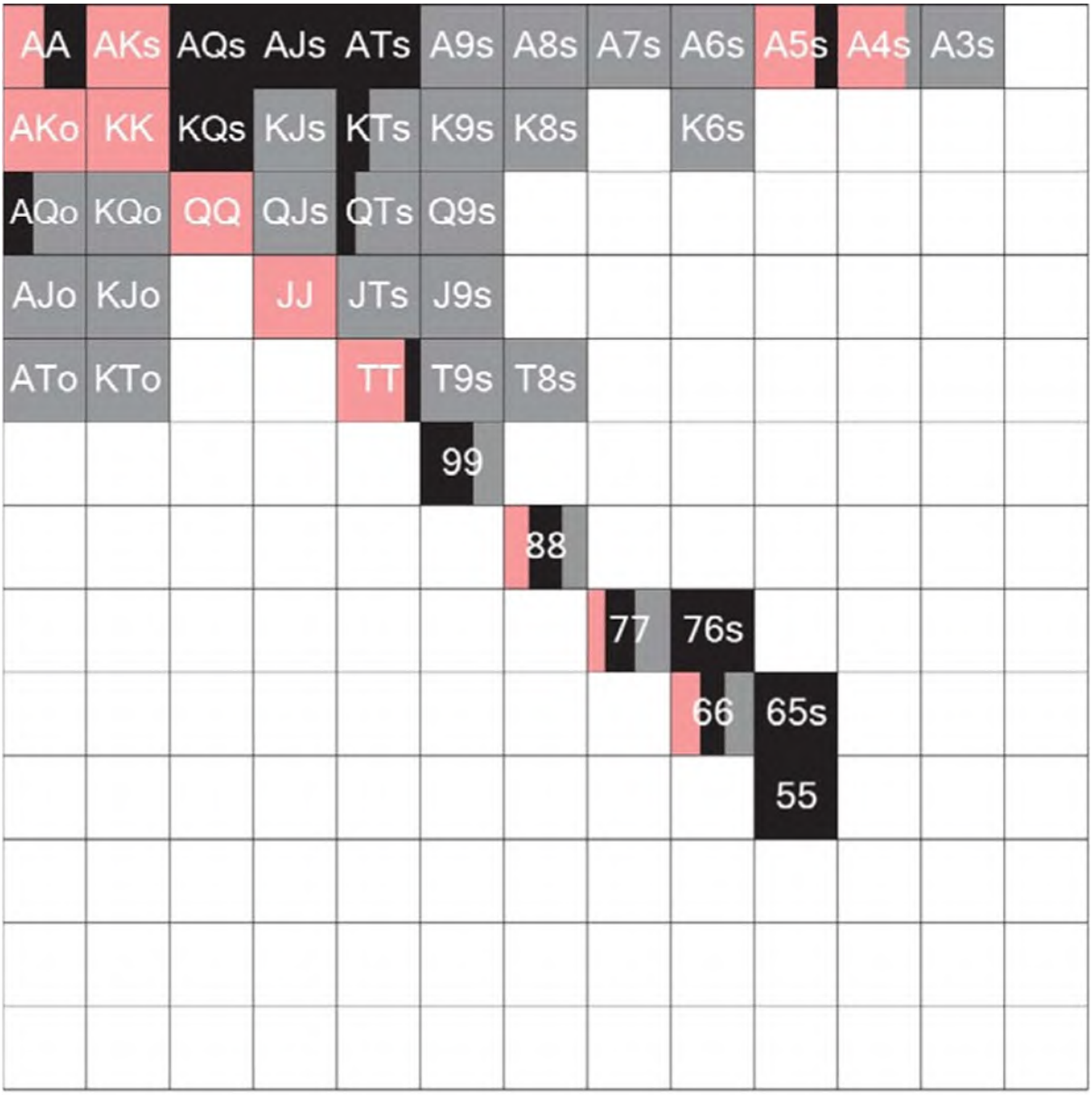
Hand Range 318: UTG 40bb vs BB 3.5x 3-bet • All-in 10% / • Call 49.5% / • Fold 40.5%



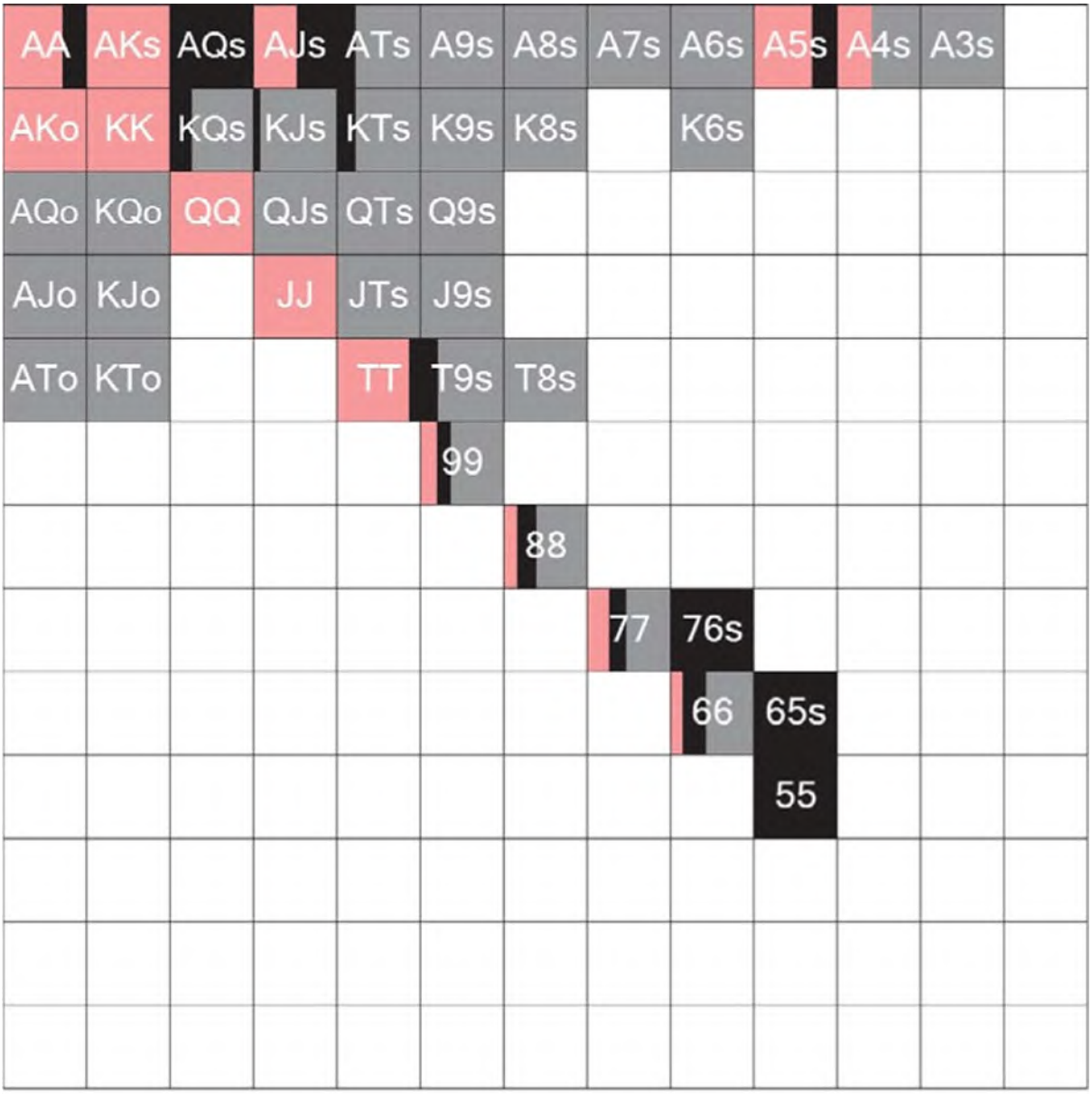
Hand Range 319: UTG 40bb vs SB 3.3x 3-bet • All-in 12.5% / • Call 50.8% / • Fold 36.7%



Hand Range 320: UTG 40bb vs BN 3.25x 3-bet • All-in 24.3% / • Call 26.3% / • Fold 49.4%



Hand Range 321: UTG 40bb vs HJ 3.25x 3-bet • All-in 25.4% / • Call 18.9% / • Fold 55.7%



Hand Range 322: UTG 40bb vs UTG+1 3.25x 3-bet • All-in 26.1% / • Call 9.7% / • Fold 64.2%

Big Stack Open vs Non-all-in 3-bet (60-80bb)

Tables 86-87 demonstrate the action frequencies when facing a non-all-in 3-bet in terms of your position.

Position	All-in	4-bet	Call	Fold	Total 4-bet
BN	1.83%	6.13%	48.58%	43.48%	7.95%
CO	1.23%	7.60%	52.60%	38.58%	8.83%
HJ	0.50%	6.63%	56.40%	36.48%	7.13%
LJ	0.25%	7.13%	57.15%	35.48%	7.38%
UTG+2	0.90%	5.63%	57.58%	35.90%	6.53%
UTG+1	0.70%	5.13%	57.65%	36.53%	5.83%
UTG	1.25%	4.58%	58.05%	36.13%	5.83%
Average	0.95%	6.11%	55.43%	37.51%	7.06%

Table 86: Action Frequencies Versus the Blinds Non-all-in 3-bet (IP)

Position	All-in	4-bet	Call	Fold	Total 4-bet
CO	1.05%	17.40%	38.65%	42.90%	18.45%
HJ	1.45%	17.50%	40.98%	40.08%	18.95%
LJ	0.58%	18.58%	39.12%	41.72%	19.17%
UTG+2	1.19%	18.70%	38.00%	42.11%	19.89%
UTG+1	2.35%	18.20%	35.95%	43.50%	20.55%
UTG	3.89%	18.14%	34.88%	43.08%	22.03%
Average	2.17%	18.23%	37.10%	42.51%	20.40%

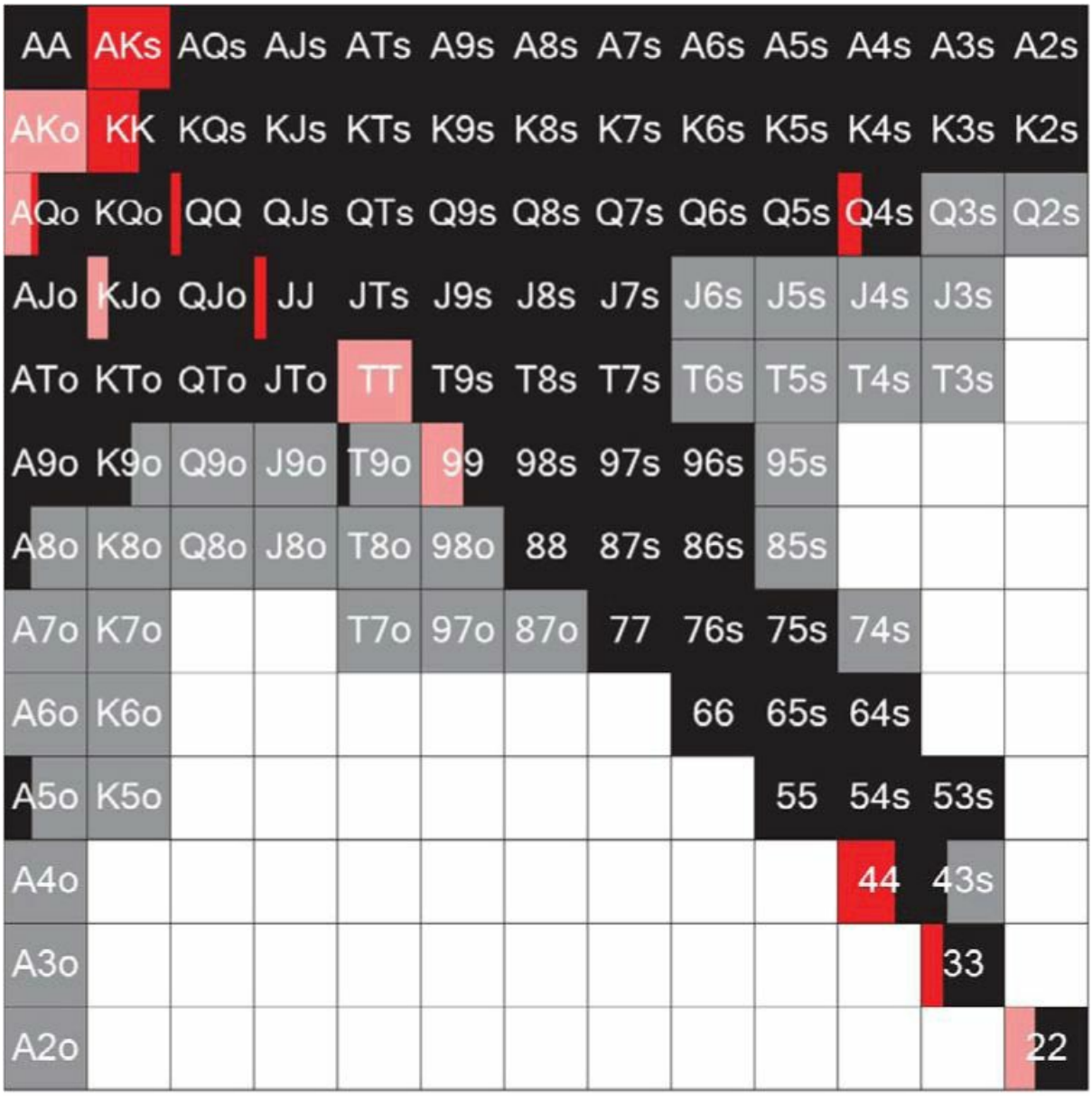
Table 87: Action Frequencies Versus Other Positions Non-all-in 3-bet (OOP)

With deeper stacks of 60-80bb the all-in 4-bets start to disappear and get replaced by non all-in 4-bets. At this stack depth the overall 4-betting frequency when having position is almost half of what it was with 25-40bb, and the OOP 4-betting frequency lowers from 22.84% to 18.23%. On the other hand, the calling frequency increases in both cases, as having a bigger stack makes playing post-flop more enticing (especially when having position) and many hands are happy to simply take the flop instead of 4-bet/fold and lose their equity in the pot.

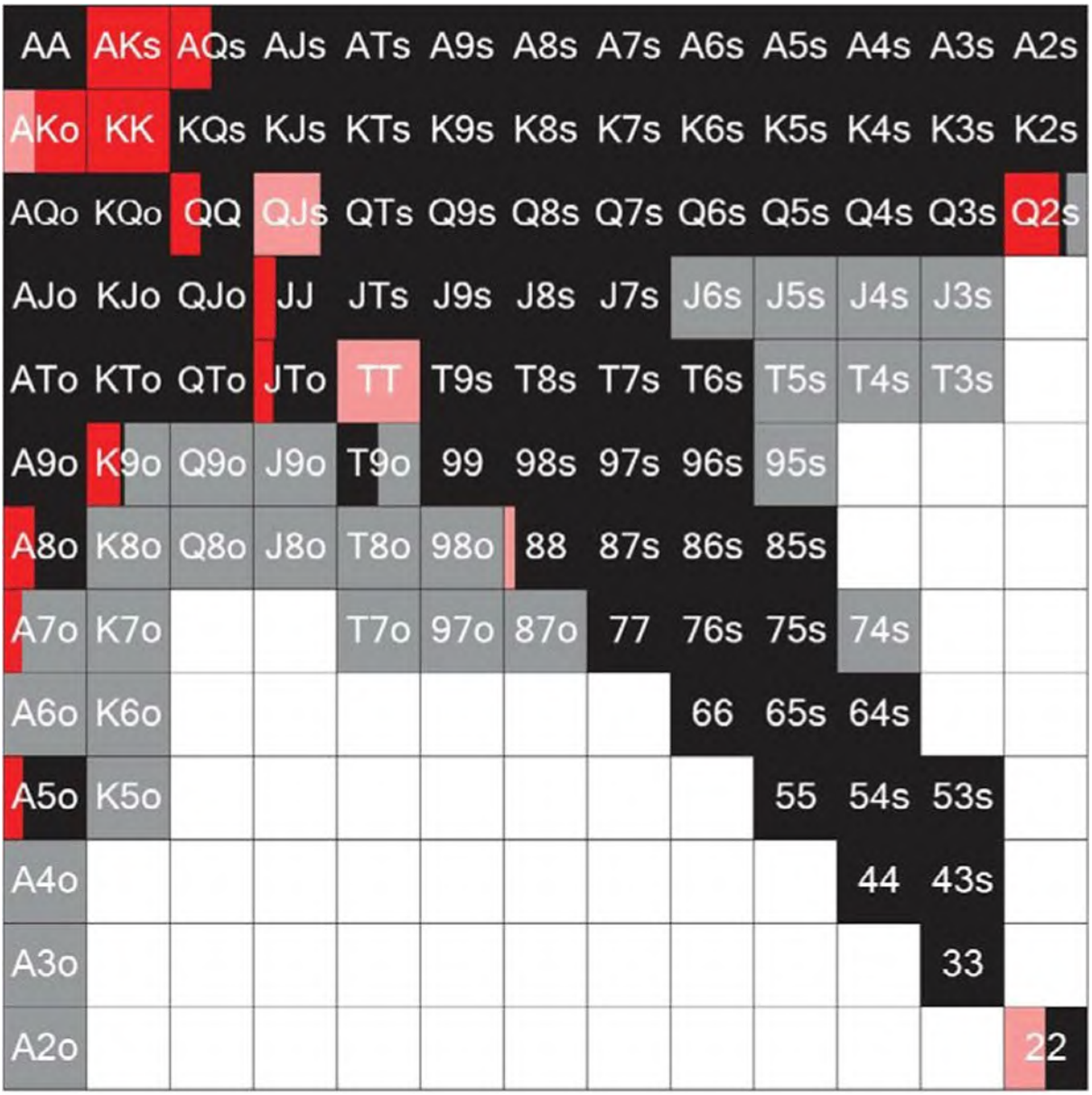
As seen before, with bigger stack depths and particularly when the opener has position on the 3-bettor, there is a big incentive for the opener to call the 3-bet and play post-flop IP. For this reason, the blinds should size up their 3-bets when stacks are deeper. If they fail to do so, the opener gets to call a very wide range and realize the equity of many hands they would otherwise have folded. The action frequencies presented here assume the players use big enough bet-sizes.

Playing vs 5-bets after 4-betting becomes pretty straightforward. In general, call any premium

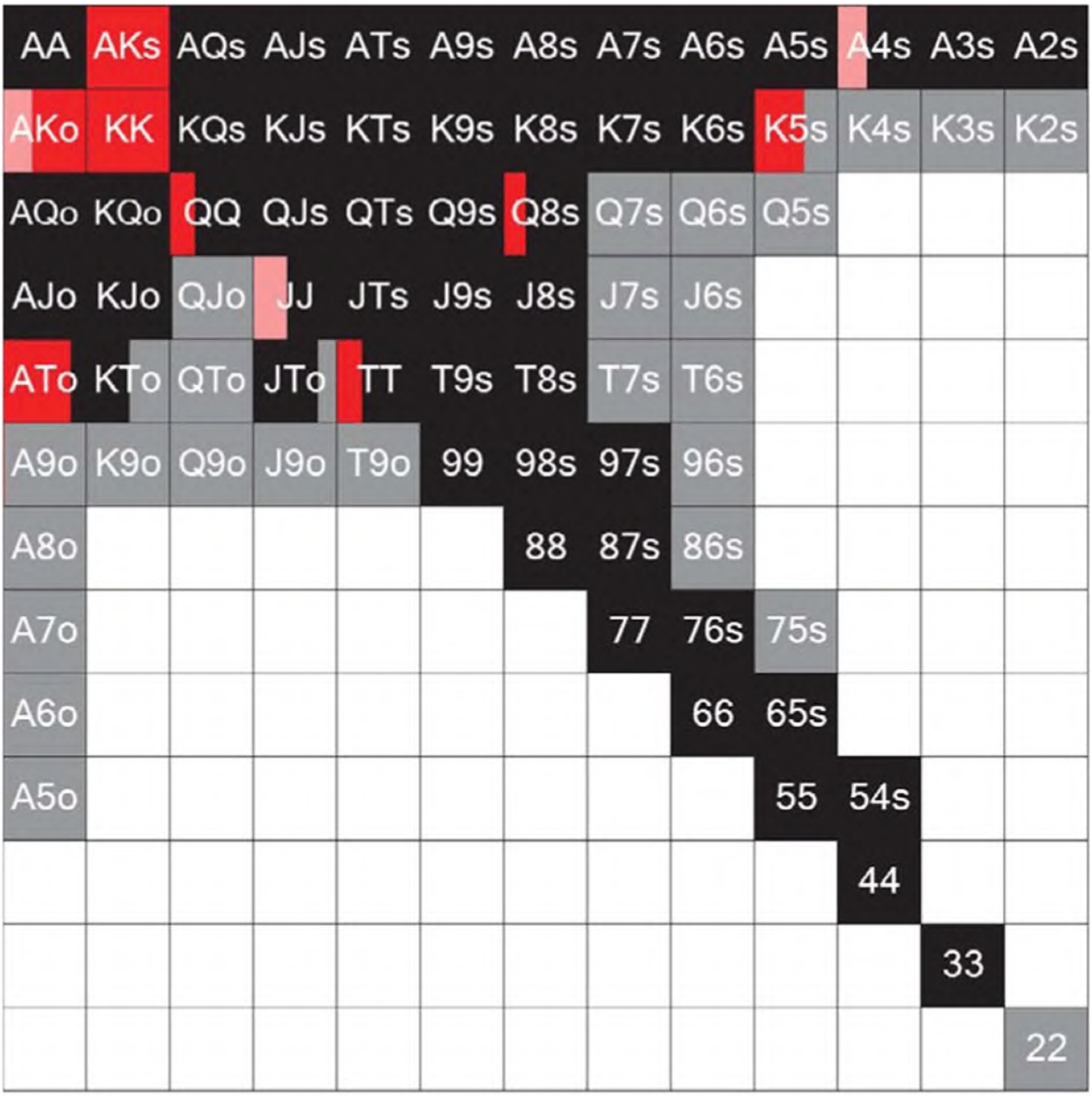
hand and fold your blocker type bluffs. EP could very well play a non 4-betting strategy vs the blinds because there aren't that many hands that really want to 4-bet in position given how polarized the blinds' 3-betting ranges are.



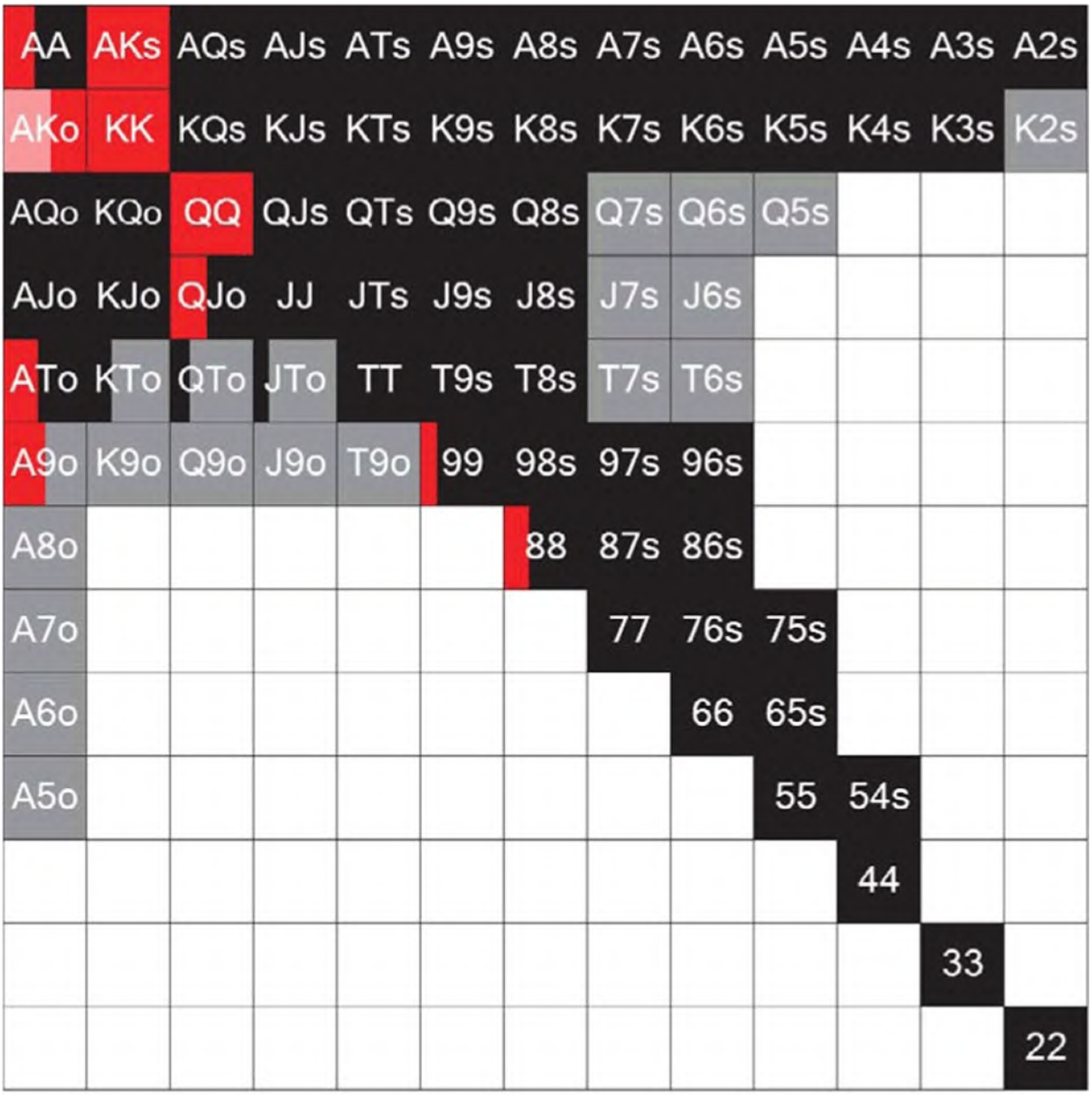
Hand Range 323: BN 60bb (2.3x vs BB 3-bet) • All-in 3.5% / • 4-bet 3.9% / • Call 52.4% / • Fold 40.2%



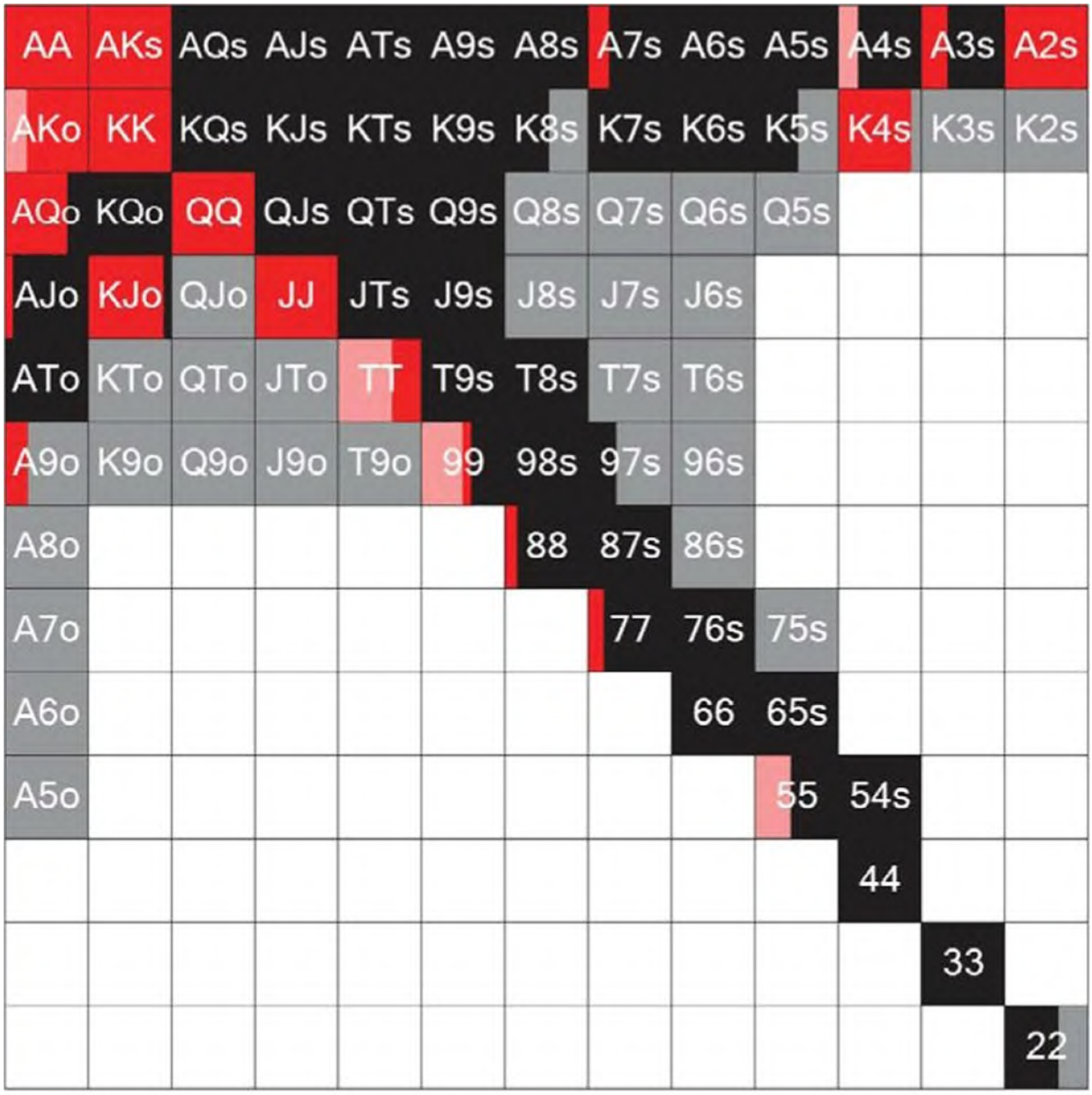
Hand Range 324: BN 60bb (2.3x vs SB 3-bet) • All-in 2.4% / • 4-bet 6% / • Call 55.8% / • Fold 35.8%



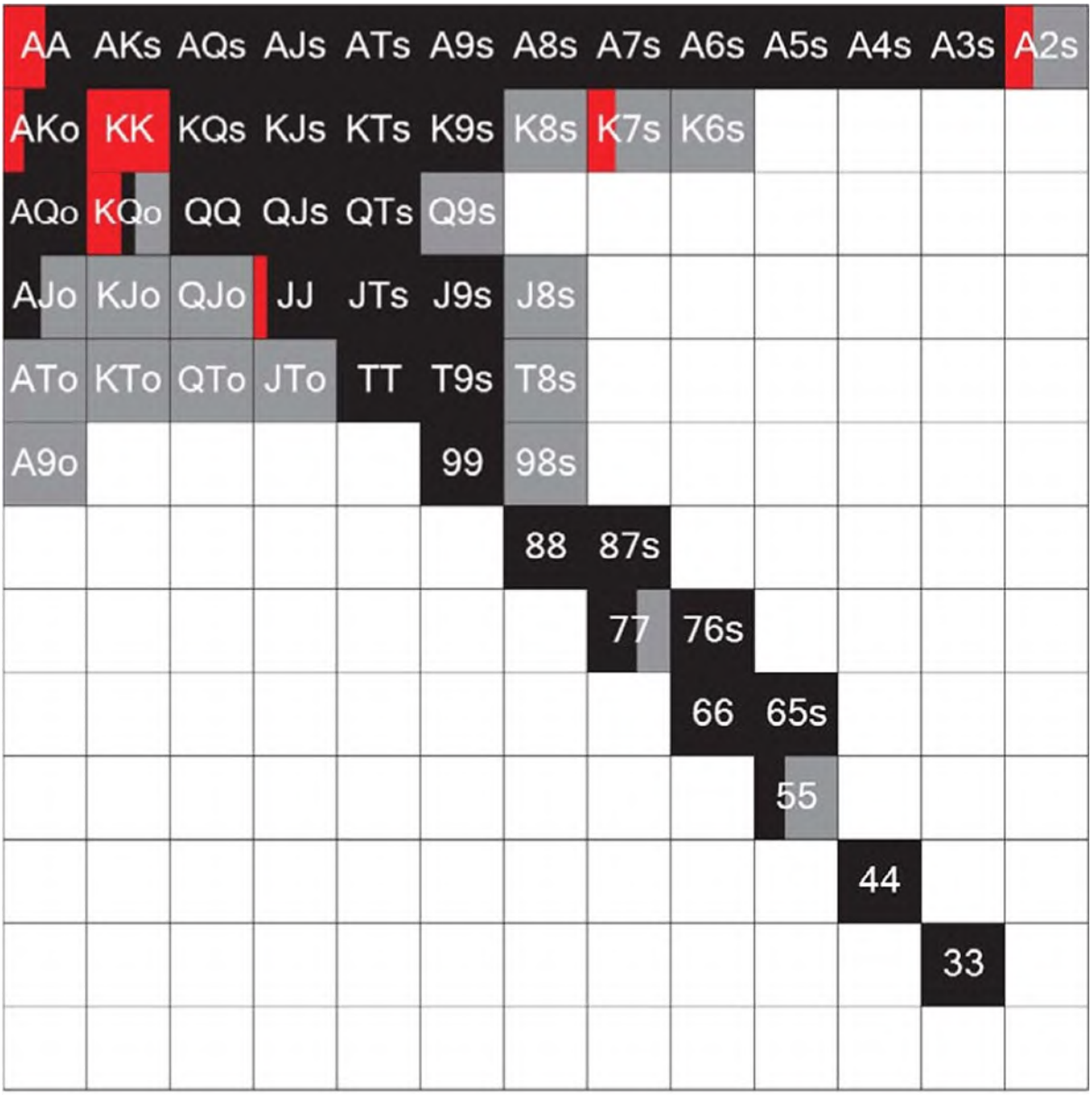
Hand Range 325: CO 60bb (2.3x vs BB 3-bet) • All-in 1.6% / • 4-bet 7.1% / • Call 52.2% / • Fold 39.1%



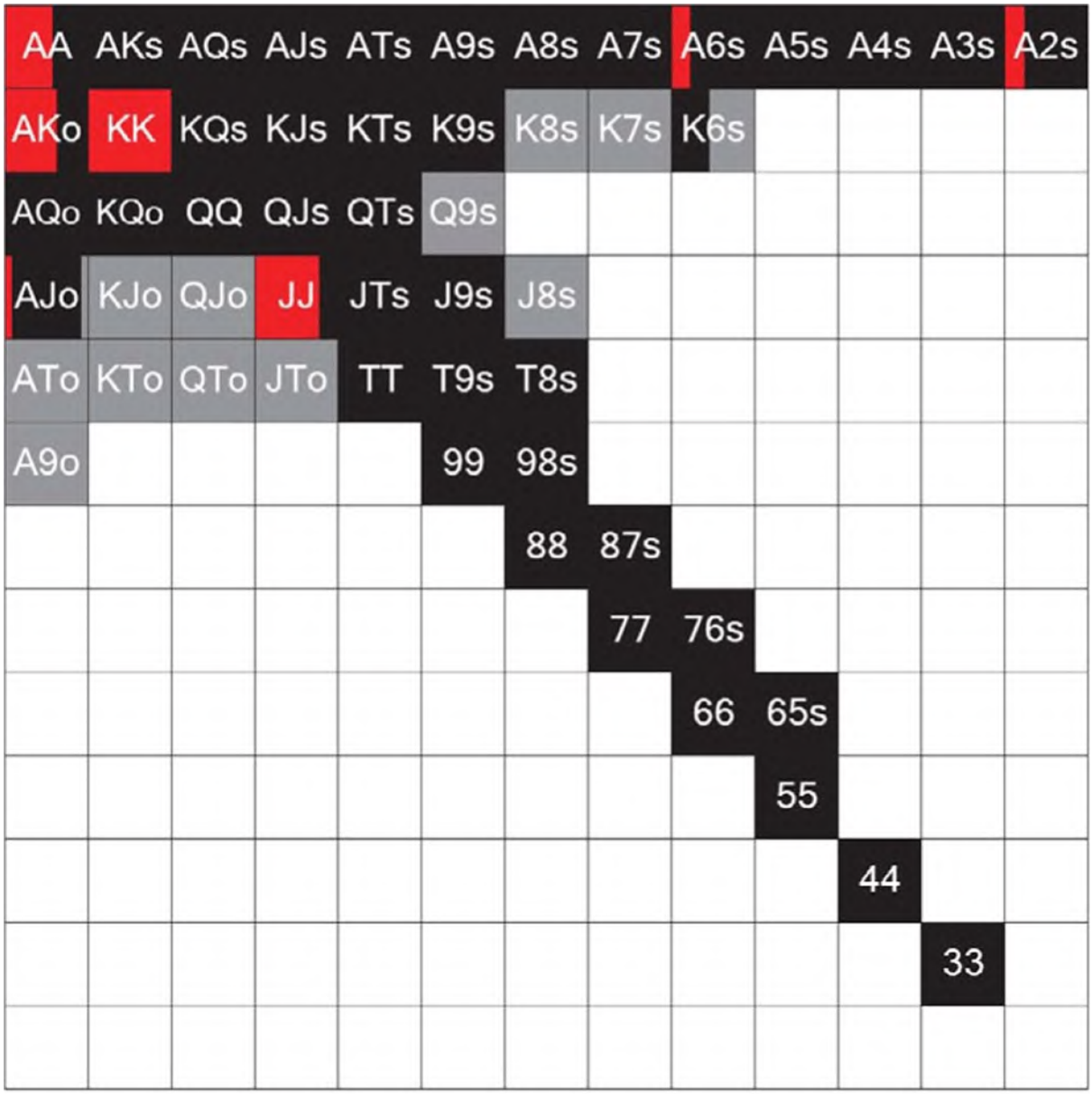
Hand Range 326: CO 60bb (2.3x vs SB 3-bet) • All-in 1.4% / • 4-bet 8.7% / • Call 58.6% / • Fold 31.3%



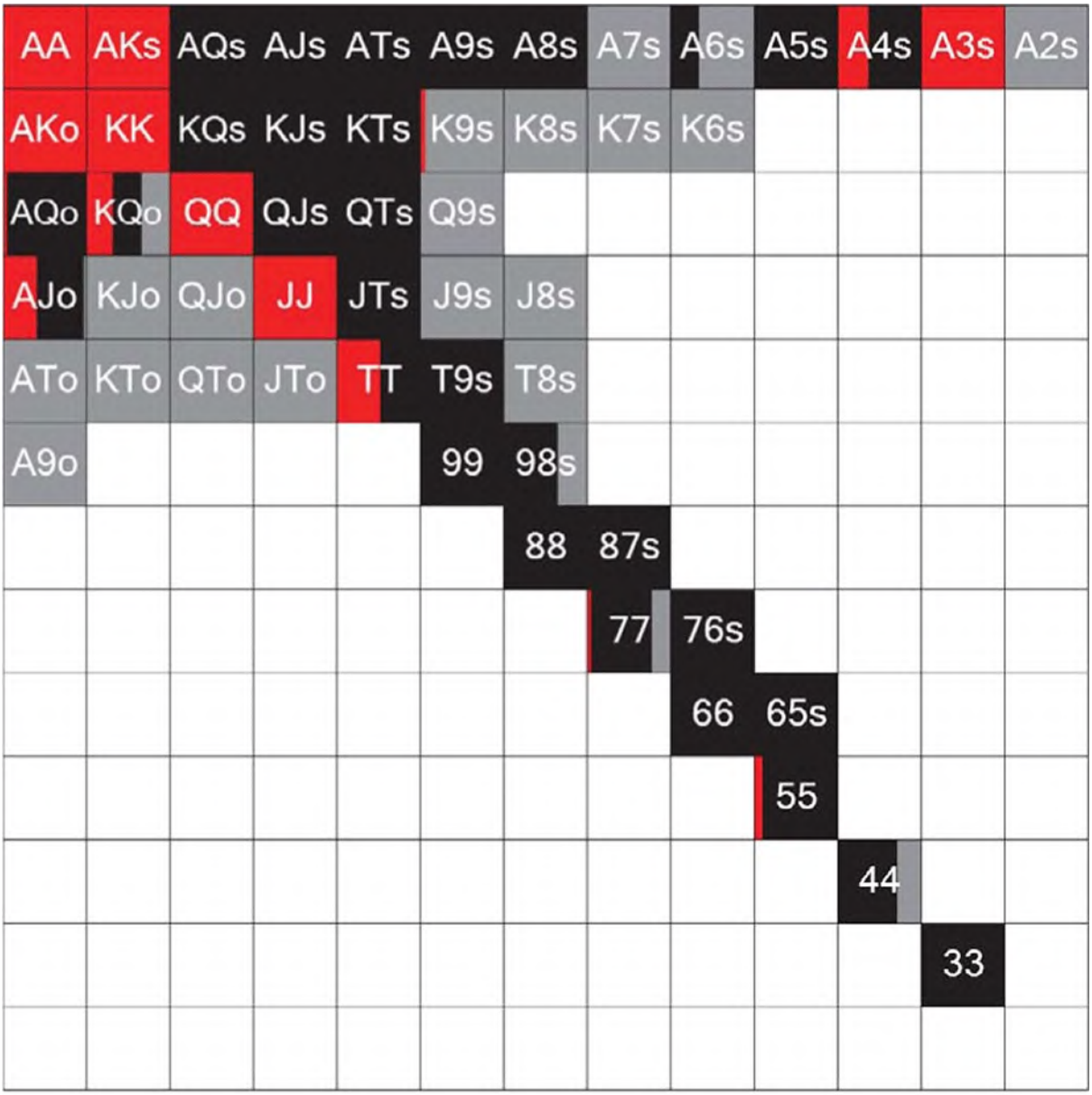
Hand Range 327: CO 60bb (2.3x vs BN 3-bet) • All-in 2.8% / • 4-bet 15.5% / • Call 39% / • Fold 42.8%



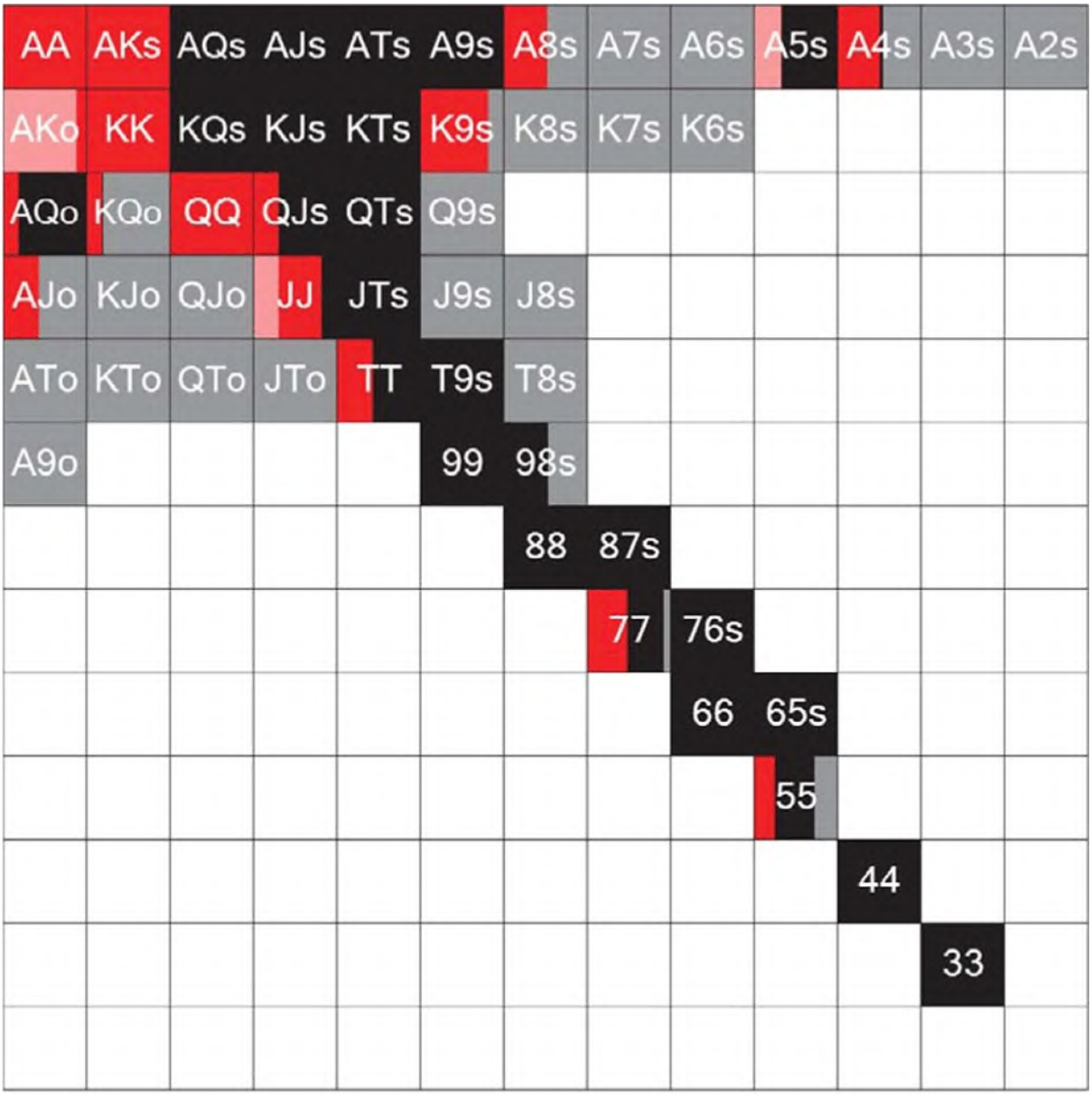
Hand Range 328: LJ 60bb (2.3x vs BB 3-bet) • All-in 0% / • 4-bet 6.8% / • Call 56.1% / • Fold 37.1%



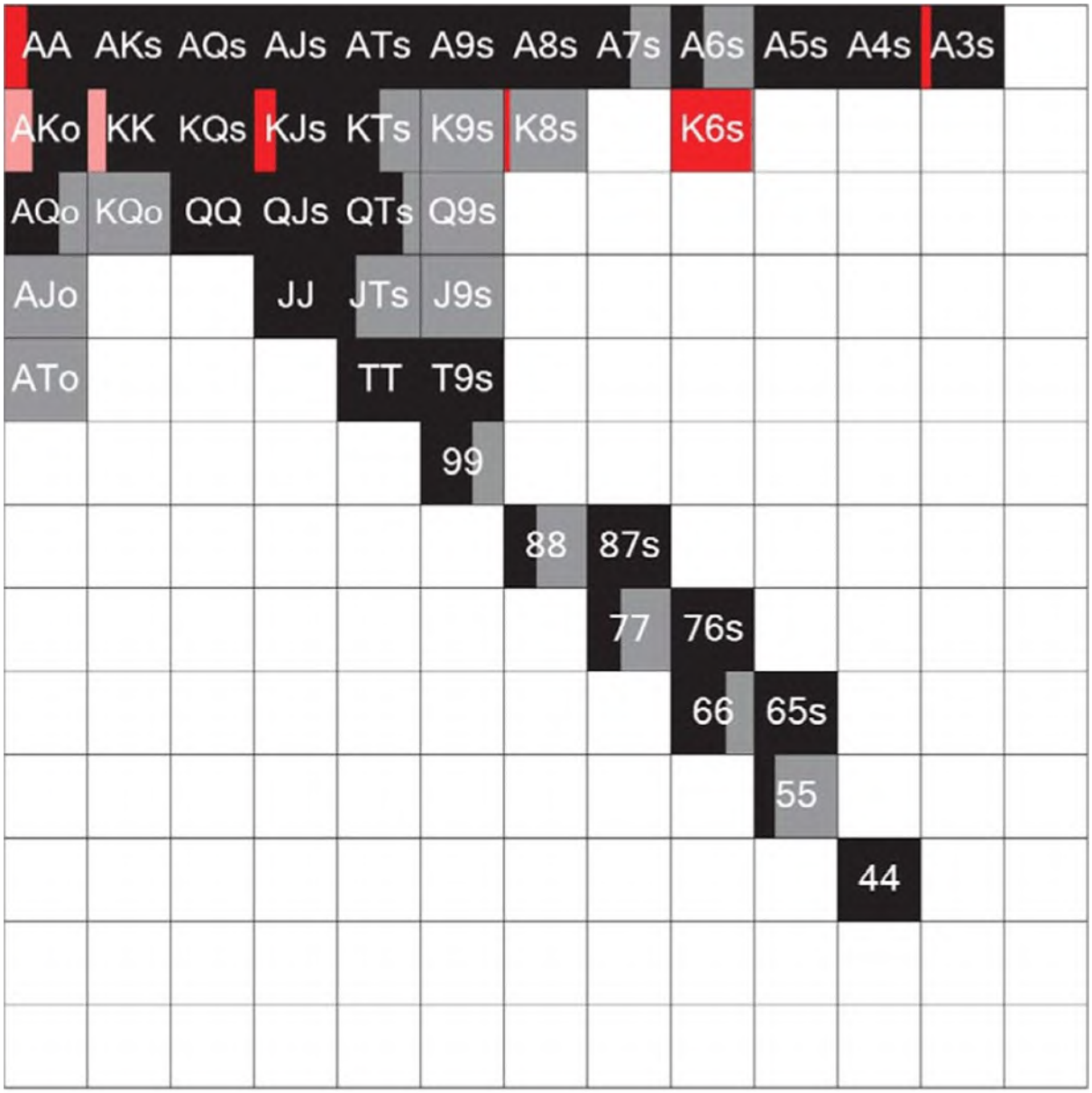
Hand Range 329: LJ 60bb (2.3x vs SB 3-bet) • All-in 0% / • 4-bet 8% / • Call 64.1% / • Fold 27.9%



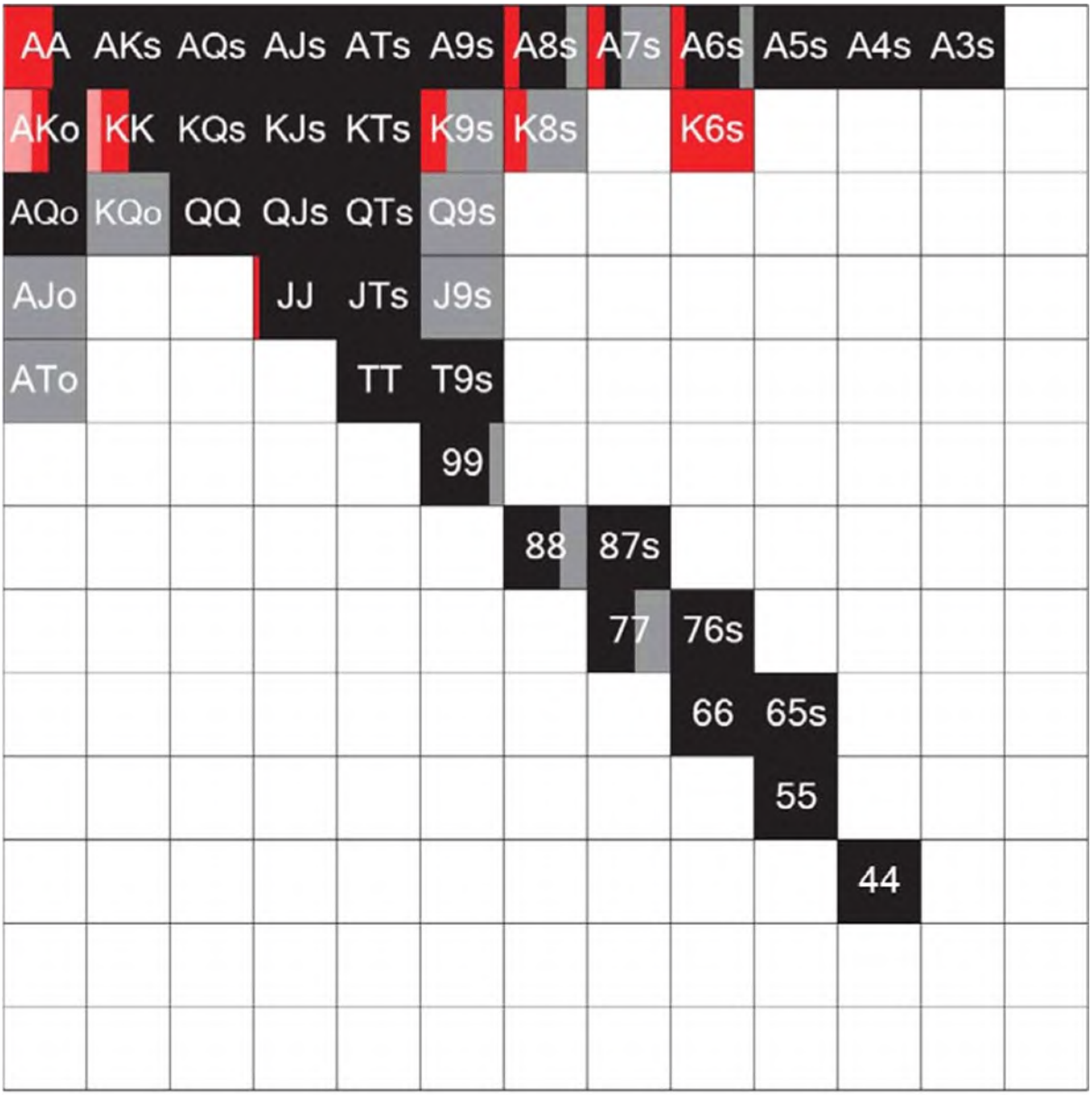
Hand Range 330: LJ 60bb (2.3x vs BN 3-bet) • All-in 0% / • 4-bet 19.2% / • Call 42.3% / • Fold 38.5%



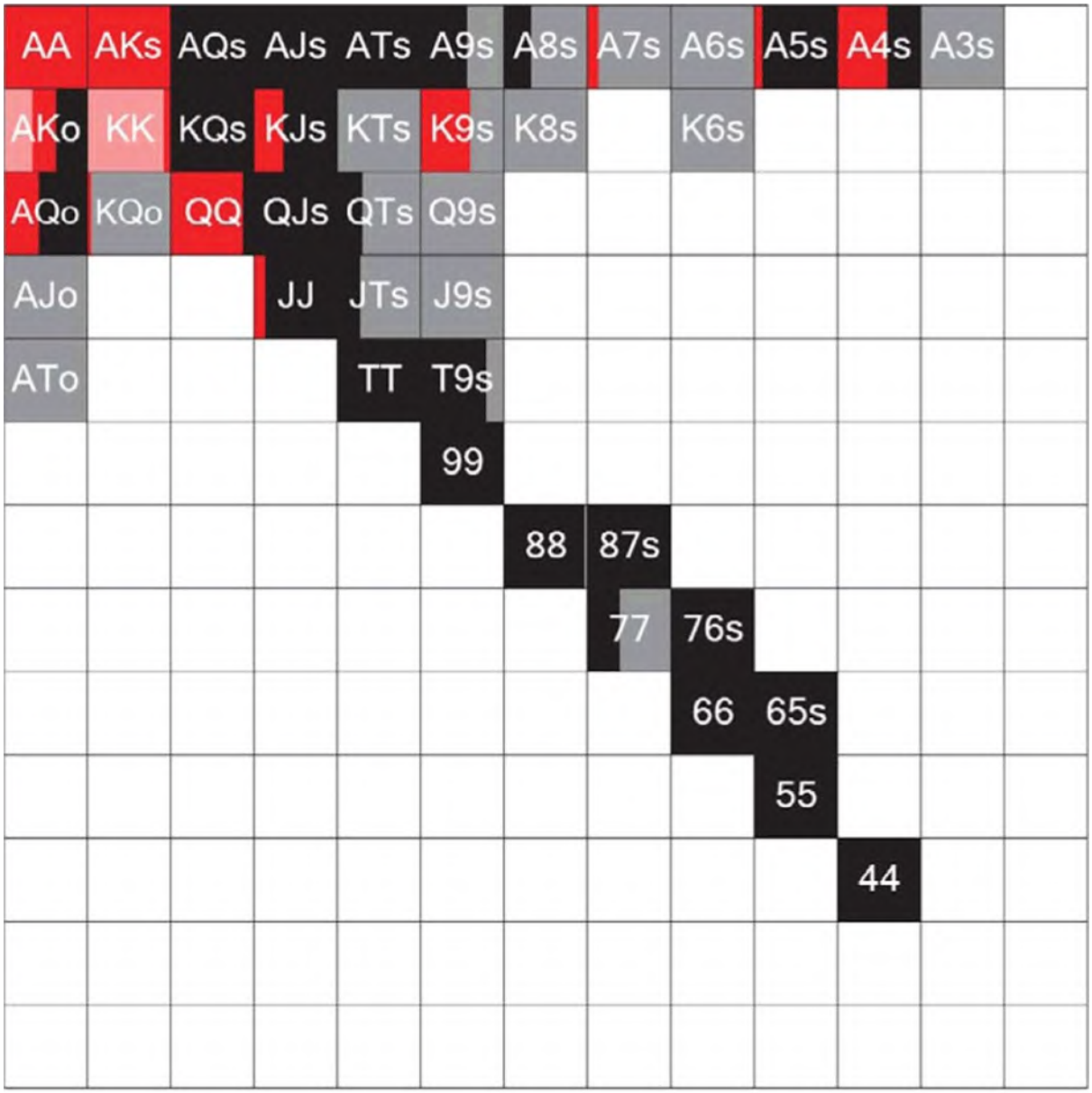
Hand Range 331: LJ 60bb (2.3x vs HJ 3-bet) • All-in 4.5% / • 4-bet 16.9% / • Call 34.3% / • Fold 44.3%



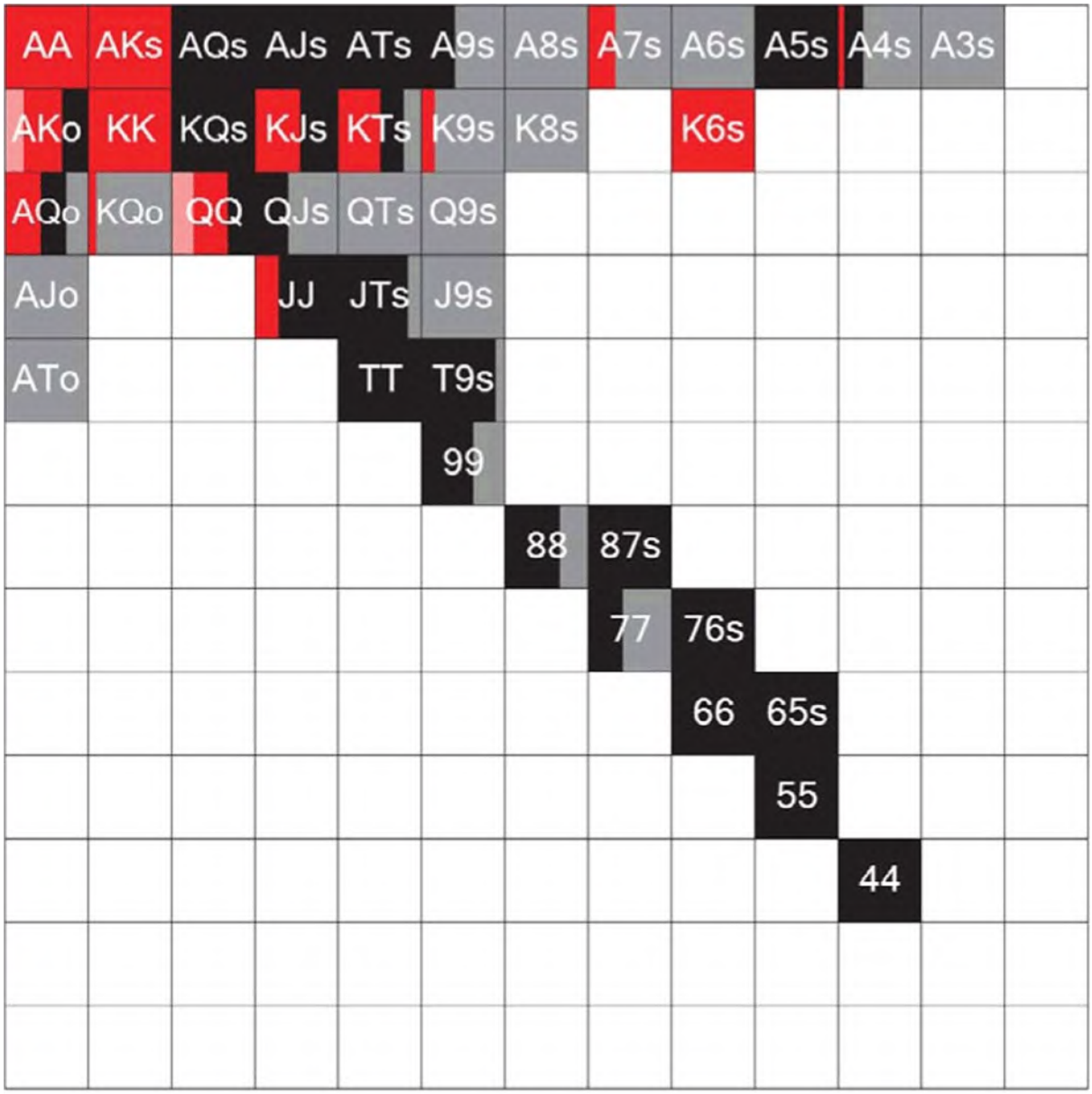
Hand Range 332: UTG 60bb (2.3x vs BB 3-bet) • All-in 2.7% / • 4-bet 1.6% / • Call 59.5% / • Fold 36.2%



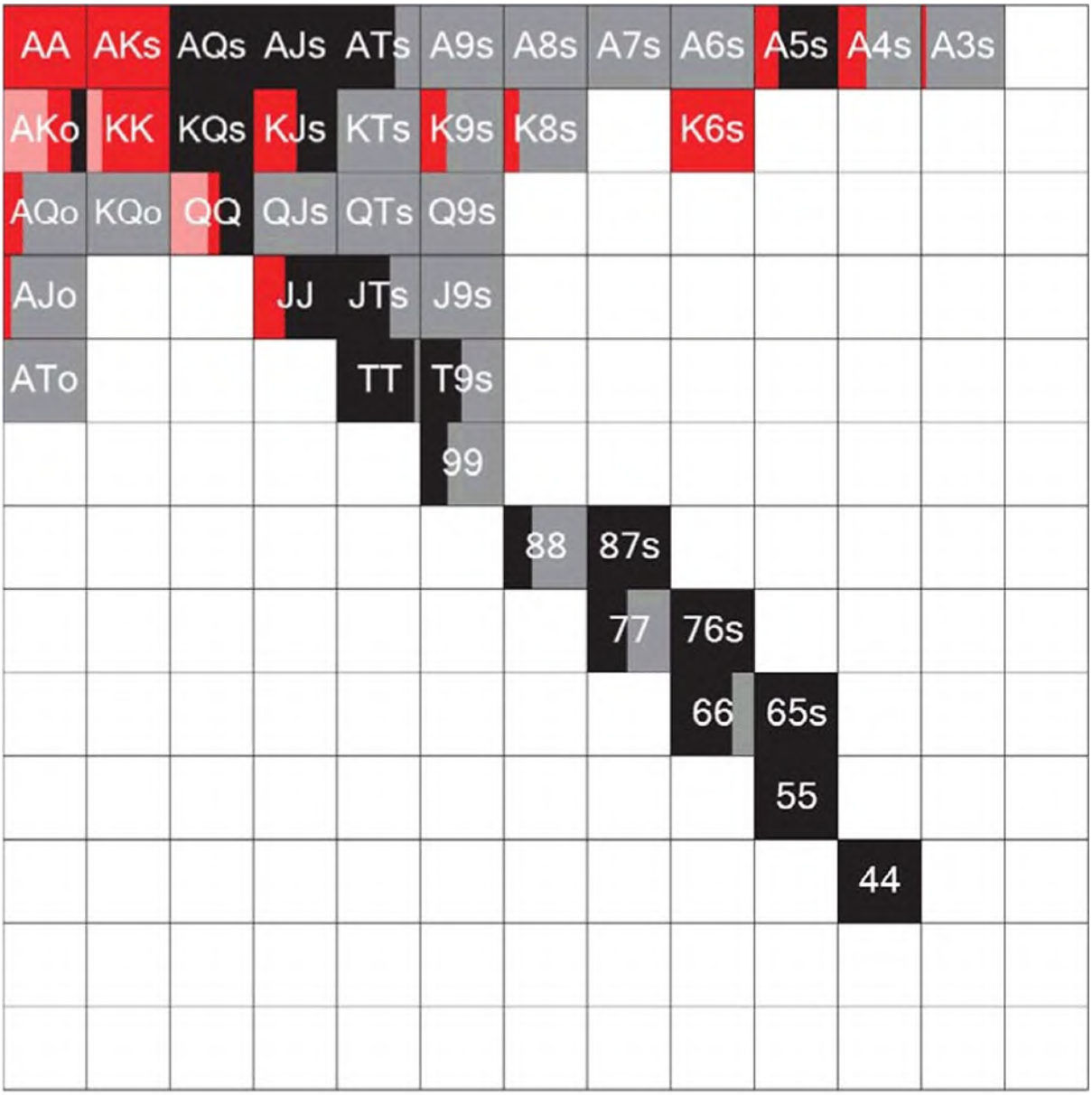
Hand Range 333: UTG 60bb (2.3x vs SB 3-bet) • All-in 2.5% / • 4-bet 6.3% / • Call 64.8% / • Fold 26.3%



Hand Range 334: UTG 60bb (2.3x vs BN 3-bet) • All-in 4.8% / • 4-bet 16.0% / • Call 43.6% / • Fold 35.5%



Hand Range 335: UTG 60bb (2.3x vs HJ 3-bet) • All-in 2.1% / • 4-bet 19.0% / • Call 38.5% / • Fold 40.4%



Hand Range 336: UTG 60bb (2.3x vs UTG+1 3-bet) • All-in 5% / • 4-bet 15.8% / • Call 28.2% / • Fold 51%

THE THEORY OF

POST-FLOP PLAY

The post-flop strategies and principles presented in this chapter are based on aggregated data from thousands of GTO simulations, analyzed with custom made software. The ranges and betting structure are representative of ante games with no rake reflecting a multi-table tournament with stack depths 20bb to 40bb but the overall results and heuristics developed from them are applicable to most NLH post-flop situations and can be extended to different stack depths and other game variants.

All the charts and metrics used in this chapter are generated from GTO solutions that are representative of some of the most important post-flop situations, providing good approximations that can help us better understand post-flop play. However, they are not a definite answer and should not be taken as the final word when it comes to poker play in general. If you want to know more about this please visit www.gtopoker.io.

Post-flop can be divided into three streets; flop, turn and river. While entire books could be written for each individual street even then we would not be close to discussing everything there is to be said about post-flop play.

I have done my best to organize the data in what seems to me to be a logical way. The emphasis will be on finding patterns, spotting trends and developing heuristics that can be easily recognized and applied in games across all three streets.

Theory of Betting

Why do we bet in poker? If you ask around, most players do not really know how to answer this question. Some people bet because they feel like it. Others might bet because they really like their hand or because they sense weakness in their opponents and think they can get away with it. Perhaps there are many possible draws on the flop and so they want to bet for protection. While all these reasons may be somewhat valid, they are still far too subjective.

Some professionals and people who watch training videos who are a bit more advanced will tell you something like “a bet has to be either for value (to get called by a worse hand) or a bluff (to make a better hand than ours fold).”

This definition sure sounds a lot more accurate than the previous ones, but is still incomplete because there are many situations where betting is the correct play even if you will only get called by better hands and will never make a better hand than yours fold.

It is important tried to stop thinking about poker by categorizing bets as only bluffs or value-

bets because that only makes sense on the river if you have a perfectly polar range and are betting against bluff-catchers. In all other situations, betting is more complex than that.

Betting as a "bluff", "for value", etc. are results of betting, not the reasons to bet. If you bet and your opponent calls with worse, you made a value-bet. If they fold a better hand than yours, you made a successful bluff.

Those are just possible outcomes of betting your hands against a range distribution, and they depend on the actual holding your opponent had at the time you made the bet, which is something you don't control. Thus, many times when you bet, you don't know exactly if you are value-betting or bluffing.

If you think about betting in a more scientific and methodical way by applying game theory concepts, you can reduce the reasons for betting to two primary concepts:

♦ Leveraging the advantage of knowing your own cards.

♦ Realizing equity or prevent your opponent's equity realization.

Leverage the Advantage of Knowing Your Own Cards

In a GTO poker model it is assumed that your opponents know your full strategy. So, you are never going to surprise a GTO opponent by holding something like 72o on the flop after you open from UTG because if you did open 72o, it would be part of your UTG RFI range and your GTO opponents will have full knowledge of that range. In that case, you should play only solid ranges that won't be easy to exploit even if the Villains have full knowledge of them.

However, even in this GTO model you still have an informational advantage over your opponents. You know what exact cards you have whereas they only know your range. The informational advantage you have is the difference between your actual holdings and your range, and this informational advantage is valuable when the decision your opponent should make varies greatly depending on your exact holding.

For example, imagine three different types of hands you could have in a given poker situation:

Hand type A, Hand type B and Hand type C.

Now imagine your opponent's correct play is to:

♦ **Fold** when you hold a hand type A

♦ **Call** when you hold a hand type B

♦ **Raise** when you hold a hand type C

If your betting range consists only of hands type A, your opponent's play will be trivial. All they have to do is always fold when you bet. Similar principles apply for the other types of hands.

By incorporating different types of hands in your ranges, you make it more difficult for your opponents to consistently make the correct play against you. So, diversity of range increases your informational advantage and makes it so that you can force your opponents into making mistakes.

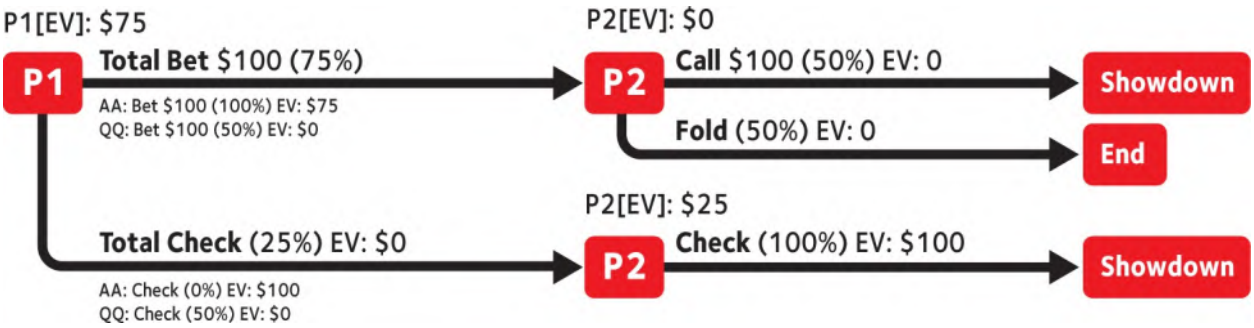
> *A mistake is defined as a decision they would not have made if they could see your hole cards, not a decision that is bad against your range.*

This is a different type of mistake that does not happen when you play against a GTO opponent who has perfect knowledge about your strategy.

An example of a mistake a non-GTO player could make against your range would be when you have a perfectly polarized range (hands with either 100% or 0% equity) and your opponent goes all-in with a bluff catcher, making your play trivial. You simply call when you have the winning hand and fold the losing hand every time. Giving your range composition, the Villain's correct play against your range should be to always check, then when you bet, he has to call with some frequency depending on your bet-sizing. Sometimes Villain will call and lose when you are value-betting and sometimes, Villain will fold when you are bluffing. This is the type of mistake you can force a GTO player to make even when they have perfect information about your range composition.

Strong ranges are ranges where the informational advantage is very valuable and that is when the Villain's correct play varies drastically depending on what part of your range you are holding at that specific time.

Let's recall the solution of the clairvoyance toy game with $100 stacks and a pot of $100. The EV of the game for P1 is $75. Thinking about this game from an informational standpoint, P1 has perfect information, as the opponent's range is exactly one hand, KK, and P2 has the worst amount of information possible. They know Villain has equal probability of having two hands and the correct action when facing a bet is the complete opposite depending on which of those hands Villain holds.



Now let's imagine P1 had only one type of hand in their range, either the nuts or air. P2 would again have an easy decision. In this case, the action of betting would not have any value at all because P2 would never call a bet when P1 has AA and P2 would always call when P1 had QQ. So again, P1 would never bet. In this case, each player's EV would be $50, but in the original toy game where P1's range is 50% AA and 50% QQ, betting has value, and the way to measure the value of having the option to bet for P1 is to compare the EV of the toy game with the option to bet against the toy game where the option to bet is removed:

$$EV[P1\ betting] = EV[Game\ with\ betting\ alowed] - EV[Game\ without\ betting\ option]$$

$$EV[P1\ betting] = \$75 - \$50 = \$25$$

In this toy game, the strategic option of betting for P1 has a value of $25 and the reason P1 is able to extract value by betting is because of range composition. Furthermore, if the cards were face-up, P2 would only call when seeing P1 has QQ and would never call when P2 has AA. If the cards were face-up, betting would not make any sense and they might as well as check 100% and realize 100% of their equity, resulting in an EV of $50 each.

With the hands face-up, P1's advantage disappears. The original solution to this game is for P1 to bet 100% of the time with AA and 50% of the time with QQ, but P1 would not be able to execute this strategy if playing face-up. All of the EV P1 gets from betting comes from this asymmetrical information. There is no reason for P1 to bet except for the advantage gained by knowing their hole cards and the fact that Villain does not.

A similar thing happens when you play real poker and there are cards still to come. If you play your range in a manner that effectively turns your hand face-up, your opponents could very easily take advantage. For example, imagine your betting range is heavily unbalanced towards flush draws on a two-tone flop. In that case, the correct play for the Villain would be to call the bet, and then play very aggressively on blank turns. So, having range diversity can be extended

to a concept called board coverage. Having good board coverage means that your range can make strong hands on a wide variety of runouts, or all of the possible runouts if you are playing perfectly balanced strategies.

The entire betting and raising dynamics in the game of poker revolve around this concept of leveraging the informational advantage of knowing your hole cards and your opponents only knowing your range. This is going to be the primary reason to bet.

> *Every time you bet, you force your opponent to make a decision and since you get to decide what your betting range is, if you build it in a way that the correct decision against you is very different depending on which part of your range you hold, then your opponent will be unable to consistently make good decisions and, as a result, will lose EV.*

In general, you want to construct your betting range in such a way that your opponent cannot possibly make the right decision consistently against all the different holdings in your range. You want to create a big discrepancy between your opponent's EV when they call and you hold hand type A in your range compared to when they call and you hold hand type B or C in your range. The same applies to raising. You want there to be a sizeable EV difference when they raise when you have hand A in your range and when they raise and you have hand B or C in your range. That is what makes a really strong betting range. The EV of folding is always 0, so in that case it doesn't matter.

Realize Equity or Prevent Villain's Equity Realization

Returning one more time to the clairvoyance toy game where P1 has a polarized range and P2 had a condensed range. As mentioned before, in this example each player has 50% equity, but P1's EV will be determined by how big their bet can be, and since their bet-size will always be all-in, their EV is directly proportional to stack depth.

If P1's stack is 10% of the pot, their EV will be $54.6. If their stack depth is 50% pot, their EV increases to $66.7. With a pot-size bet, their EV increases to $75. With 2x pot, the EV is $83.5. With 10x pot the EV is $95.4. The deeper the stacks are, the more effectively P1 can use range construction to over-realize equity and hinder P2's equity realization. So, in this toy game, it doesn't matter that P2 has 50% equity. If stacks are deep enough, P1 can always get away with capturing more than their "fair share" of the pot. Conversely, as stacks get shallower, P1 becomes less effective in denying P2 equity, which results in both players capturing a more even share of the pot.

Range composition is an important factor in determining how much more of their equity

players get to realize than raw equity.

> *When stacks are deep, more streets are left to play and the better your opponent plays, the more range balance matters and the less raw equity matters. When stacks are short, all the money will usually go in pre-flop or on the flop which makes raw equity the dominant factor.*

As stacks get deeper, play will occur across multiple streets which increases the need for constructing well-balanced ranges.

Constructing sound post-flop betting strategies is not an easy task. Not only do you need to preserve your informational advantage on the flop, but across all future streets too. Runout coverage is essential for both betting and checking ranges. If you don't have the right runout coverage, even if your flop ranges are well constructed to make your opponent's decision difficult on the flop, they could still exploit you on later streets.

Poker is a game of equity, how much you have and how to effectively realize it. Betting helps realize equity because it denies your opponent's equity and it also helps set up the SPR in a way that can be beneficial to your equity realization. Range composition is always key to determine optimal betting strategies. For this reason, in the next section, I introduce a new concept called *Equity Buckets* that will help to better understand post-flop play dynamics.

Strategic Actions

Now that we understand the action of betting conceptually, we can take a closer look at the other possible strategic actions of:

- ♦ Folding
- ♦ Checking
- ♦ Calling
- ♦ Raising

Folding

In game theory folding your hand when checking is free is a strictly dominated strategy and should therefore never be used. Even if you think your hand is really bad and you know you will be folding it to any future bets you should never proactively fold. Simply wait for your

opponents to make a bet before mucking your cards because no matter how bad your hand might be, it will always have some equity or backdoor equity against most normal range distributions. That equity can be realized if your opponents also check and allow free cards to be dealt. In some cases, you might find decent spots to turn your hand into a bluff and take the pot down later.

Most importantly though, preserving the informational advantage you have over your opponents is key. If every time you have a terrible hand you simply muck instead of checking, then when you do not proactively fold, your opponents will know that you have a good hand and will be able to adjust appropriately, only giving you action when they have a strong hand.

Folding is a valid option only when facing a bet from an opponent and you assess that no other strategic option (calling or raising) has a positive expectation.

Checking

Checking when in position is fundamentally different to checking when out of position. Checking back the flop in position effectively removes one betting street from the game tree, which benefits the weaker portions of IP's range. When you are IP, checking your option immediately realizes equity, either by seeing another card or by reaching showdown.

In contrast, checking when OOP does not guarantee equity realization because many times the OOP player will face a bet after checking and will be forced to fold some hands and forfeit equity in the pot, making the need for range balance even greater when checking OOP compared to IP. IP's checking range only has to be balanced on the average turn card, while OOP's checking range has to be balanced on the flop so it can deal with possible IP bets.

Calling

Calling a bet in a heads-up pot realizes equity, either by reaching showdown or seeing another card.

Raising

Raising a bet is effectively putting a bet on top of a previous bet, so the same principles that apply to betting also apply to raising. You only want to make a raise to leverage the advantage of knowing your hole cards or if raising can help you effectively realize equity or deny your opponent's equity realization.

All the different actions you take convey information. Once you take an action, you can only hold hands that would be present in the range that takes that action. One of the biggest mistakes I

see rookies make is trying to represent a hand that they clearly can never have given the way the action has played out. This is why it is important not only to be able to hand read your opponents correctly, but also to be aware of your own ranges and make sure to keep them well-balanced.

If the story your opponent is trying to tell you doesn't make sense, they probably don't have it.

Equity Buckets (EQB)

Earlier in Chapter 1 we discussed range morphology, and mentioned three main range shapes:

♦ Linear range

♦ Polarized range

♦ Condensed range

We also established that a range can be capped or uncapped and that most ranges will fit into one or more categories at the same time. While this way of categorizing the ranges works well for most pre-flop situations and can be used to get a general idea of a range's equity distribution, it lacks a level of detail.

As we have seen in the game theory section, range composition is one of the most important factors that drives the action. For this reason, I am introducing a new concept called *Equity Buckets*, shifting the focus from the way ranges are categorized according to their general equity distribution to the way hands within a given range can be categorized according to their hand vs range equity. This gives us the required level of detail to help us better understand post-flop play:

♦ **Strong Hands:** Hands with a hand vs range equity greater or equal to **75%**

♦ **Good Hands:** Hands with a hand vs range equity greater or equal to **50%** but lower than **75%**

♦ **Weak Hands:** Hands with a hand vs range equity greater or equal to **33%** but lower than **50%**

♦ **Trash Hands:** Hands with a hand vs range equity lower than **33%**

By putting each hand in a player's range into an equity bucket, we get a clearer idea of the

range's post-flop equity distribution and can be more precise about the degree to which a range fits within the different morphologies. It is important to emphasize how a hand's value is not static but instead dynamic, relative to the ranges in play and the board type *(Table 88)*.

UTG vs BB (40bb)	Ah-Qd-Ts		Th9d8s		Td9h8h		Th9h8h	
Hand Category	IP EQ	BB EQ	IP EQ	BB EQ	IP EQ	BB EQ	IP EQ	BB EQ
Straight	94%	88%	93%	86%	90%	84%	77%	75%
Set	91%	81%	83%	82%	81%	80%	74%	73%
Two Pair	87%	68%	76%	72%	73%	69%	65%	61%
Top Pair	82%	53%	69%	58%	69%	54%	60%	51%
Middle Pair	77%	42%	66%	54%	63%	52%	54%	47%
Bottom Pair	67%	35%	56%	50%	53%	48%	45%	44%

Table 88: Sample Hand EQ Values on Various Board Types

We can see how a hand such as top pair can be strong with 82% EQ on the AQT flop but has only 60% EQ on the single suited T98 flop. A hand such as two pair on AQT has more equity than a set on T98.

BB vs IP Equity Buckets (All flops)

Average UTG vs BB and BN vs BB Flop Equity Buckets for GTO MTT Ranges with stack depths 20, 30 and 40bbs *(Diagrams 23 and 24)*.

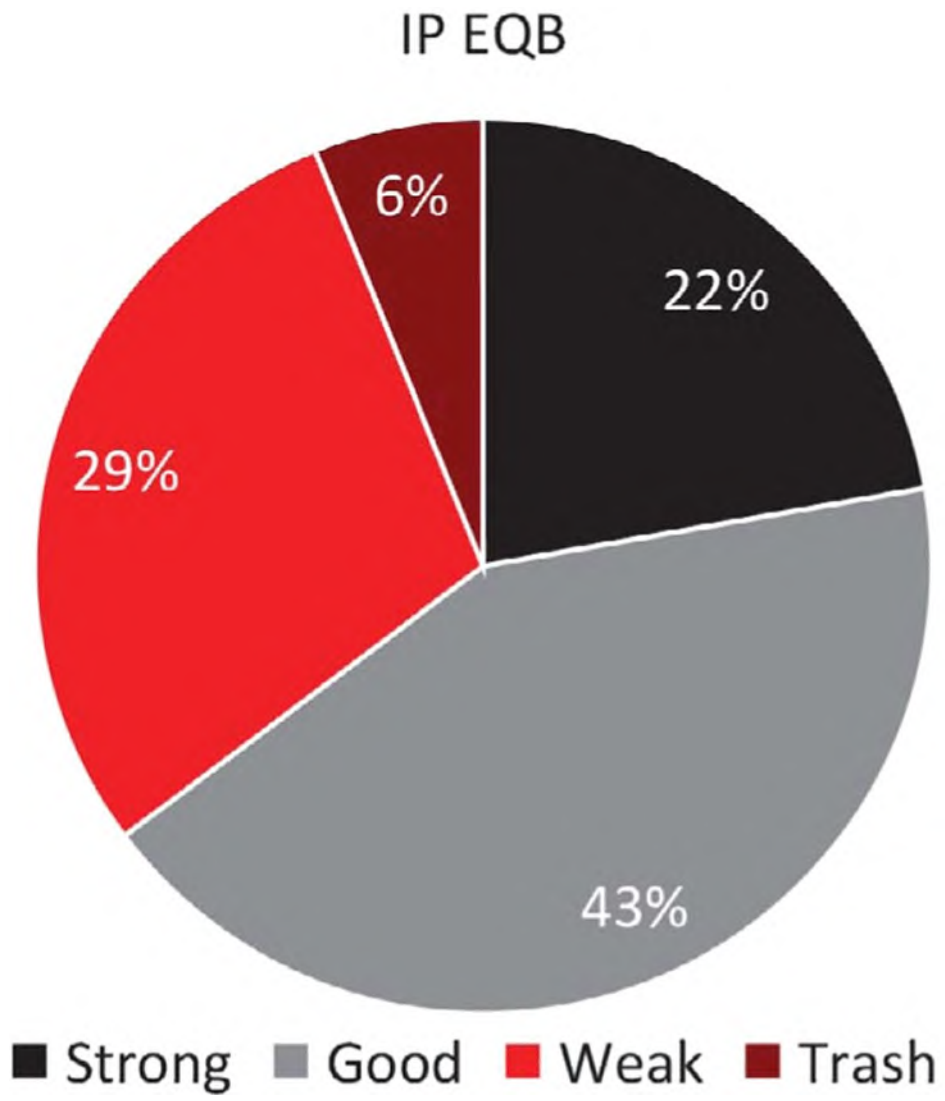


Diagram 23

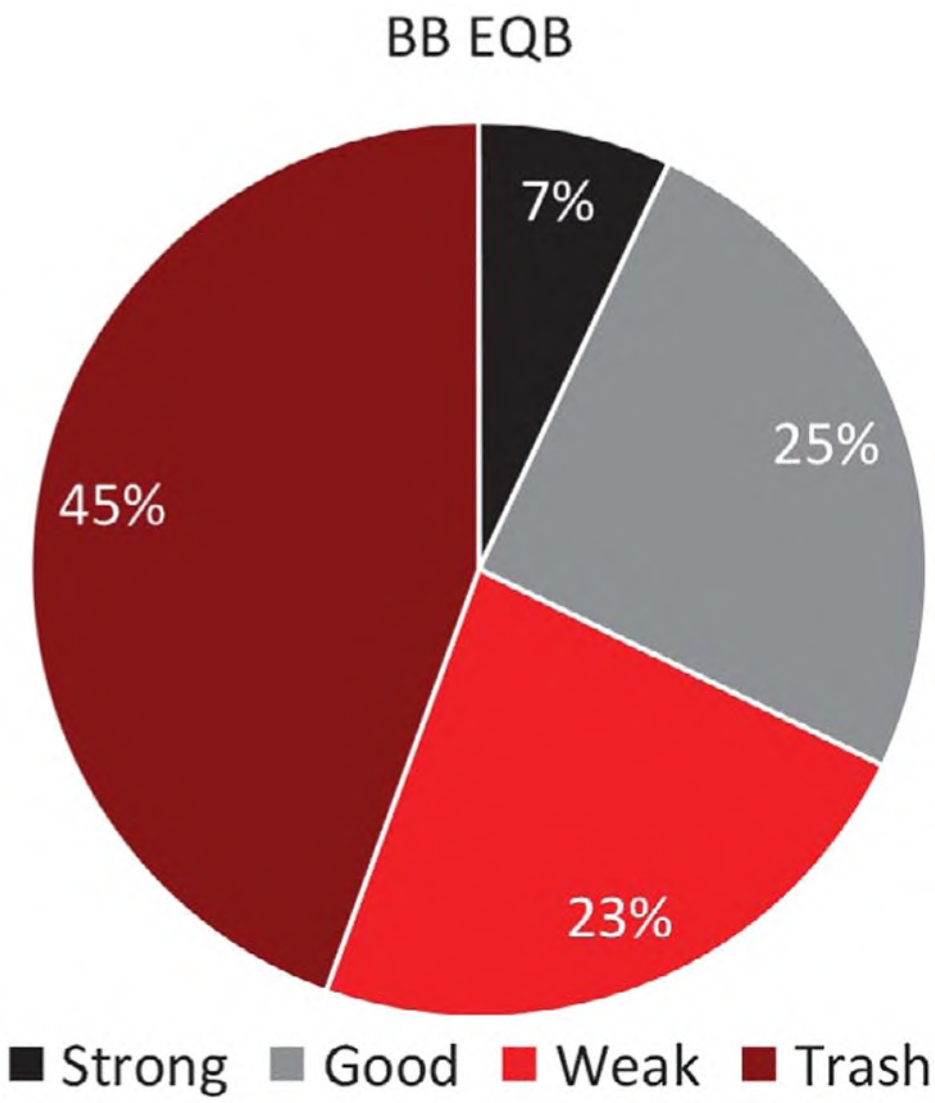


Diagram 24

According to the EQB Charts across all 1,755 flops, almost half of the BB range is made of trash hands that have less than 33% equity, while the IP Player (BN-UTG) has on average only 6% of trash hands in their range. On the other hand, the IP Player has 22% strong hands that have at least 75% equity, while only about 7% of the BB range are strong hands. Both players have a similar number of weak hands, 23% for the BB and 29% for IP. Finally, the IP Player's range has 43% good hands while the BB has only 25%.

Post-flop Bet-sizing

The main thing that sets NLH apart from other poker games is the ability to bet any amount, from a single big blind to your entire stack, at any given point. When we discussed complex strategies in Chapter 4 we proved that playing a more complex strategy than push or fold gains Hero EV. The following questions are interesting:

- ♦ How important is it to have the ability to use several bet-sizes post-flop?
- ♦ How many bet-sizes do we need?
- ♦ Does true GTO play require the use of an infinite number of bet-sizes, or is there a cap to the EV gained by adding multiple bet-sizes and increasing the complexity of our strategy?
- ♦ Could it be the case that there is a GTO optimal bet-size that will always maximize our EV?

NLH is a continuous game in the sense that the full game tree with infinite bet-sizes cannot be drawn. So, in order to computationally solve any given NLH situation with modern GTO Solvers, we must use a betting abstraction with a finite number of bet-sizes. If true optimal play requires the use of an infinite or very large number of bet-sizes, then computational solver applications would be quite limited, or even useless. Furthermore, as mentioned before, the cost of implementing extremely complex strategies can surpass the value they add and can, in practice, hurt your expectation because more complex strategies are more difficult to execute. Unlike computers, for us humans, even more than a few bet-sizes across multiple streets quickly gets out of hand.

In this section we will use results from known toy games and modern solvers to answer these questions, improving our understanding of GTO bet-sizing and use the results to develop strategies that are both powerful and simple enough to be effectively implemented.

The Pot-size Raise

The pot-size bet or pot-size raise is a bet that lays exactly 2-to-1 or 33% pot odds to your opponent. Betting the size of the pot is widely used in Pot Limit Omaha (PLO) as the biggest possible bet or raise players can make. For this reason, PLO players are probably going to be more familiar with it than NLH players.

The way to calculate a pot-size bet is straightforward. Imagine the pot is $100, and you want to bet 1/2-pot. All you have to do is multiply $100 × 1/2 = $50. But this gets a bit trickier if you

want to make a pot-size raise after someone else has already made a bet.

To calculate a pot-sized raise, follow this formula:

Match the previous bet.
Calculate the total pot including your matching bet before you raise.
Add that amount on top of your matching bet.

Example

The pot is $100 and Villain bets $50, how much should you raise if you want to make a pot-size raise?

$$Your\ Matching\ Bet\ is\ \$50$$

$$Total\ Pot\ Including\ Your\ Matching\ Bet = Starting\ Pot + Bet\ Faced + Matching\ Bet$$

$$Total\ Pot\ Including\ Your\ Matching\ Bet = \$100 + \$50 + \$50 = \$200$$

$$Pot\ Size\ Raise = Total\ Pot + Matching\ Bet$$

$$Pot\ Size\ Raise = \$200 + \$50 = \$250$$

If you want to raise to a fraction of the pot, the formula would be as follows:

$$Pot\ Size\ Raise = (\%Pot * Total\ Pot) + Matching\ Bet$$

Full pot = 100%, so the pot-size raise stays the same:

$$Pot\ Size\ Raise = (100\% * \$200) + \$50 = \$250$$

If you want to raise a different amount such as 50% pot, then the calculation would be:

$$50\%\ Pot\ Size\ Raise = (50\% * \$200) + \$50$$

$$50\%\ Pot\ Size\ Raise = (\$100) + \$50 = \$150$$

A 25% pot size raise would be:

$$25\%\ Pot\ Size\ Raise\ = (25\% * \$200) + \$50$$

$$25\%\ Pot\ Size\ Raise\ = (\$50) + \$50 = \$100$$

Alpha and MDF Revisited

EV has to be compared between all the different actions a player can take and never in a vacuum. I've seen many top players, and even famous poker coaches, making the mistake of using the *Alpha Number* and *MDF* to justify making bad plays. The discussion often goes something like this:

> *"My flop bet is profitable, it only has to work X% of the time and the Villain is folding more than that, therefore I'm making money!"*

While that statement might be true, we cannot forget where Alpha and MDF numbers come from. They are derived from the EV equation. They assume that the EV of checking back your hand is 0 and that every time you are called and hold a bluff that you lose the pot and your bet. However, on the flop most poker hands will almost always have some equity as even the worst hands can improve on future streets. For this reason, the Alpha and MDF numbers are misleading. In reality, the BB does not have to defend nearly as many hands as MDF suggests, because they do not have to make IP's worst hands indifferent to 0. IP has to make them indifferent to the EV of checking back. Also, IP won't always lose the entire pot when they are called and hold a bluff because sometimes this bluff will pick up equity which makes the continuation bets more profitable than expected.

$$Alpha = \frac{b}{b+p}$$

$$MDF = \frac{p}{(p+b)}$$

These numbers become more relevant on the river when there are no more cards to come and you know if your hand has some equity in the pot or not. When deciding whether to bet or check a hand, you need to compare the EV of both actions and take the action you think will yield a higher expectation.

Alpha and MDF can be used as a rough guide, but you cannot build your core strategy based solely on them and think it is GTO.

Splitting Your Range Into Multiple Bet-sizes

How many bet-sizes do you need on any given flop? Should you split your range as much as possible by betting different amounts according to hand strength?

The [0-1] Toy game

The [0-1] Toy Game can be used to analyze a heads-up situation when both players have symmetrical ranges. In this game, both players get dealt a random number between 0 and 1 (including decimals such as .04563) that represent their hand. Higher numbers beat lower numbers. This game is played across a single street. OOP always checks to IP who can bet or check. If IP bets, OOP can only call or fold, and cannot x/r.

In this set-up, both players can have an infinite number of hands as there are infinite numbers between 0 and 1. The general result is that the optimal strategy for IP is to use an infinite number of bet-sizes based on the strength of their value hands. So IP should pick a value hand, say 0.99, and pair it up with a bluff chosen from one of the weakest hands in the range, say 0.01. IP then bets a specific amount that varies with the strength of the value hand, using the biggest bet-size with the strongest value hand, the second biggest bet-size with the second strongest value hand, the third biggest bet-size with the third strongest value hand and so on.

We can replicate the [0-1] Toy Game in a modern GTO solver by giving both players a fixed range of 10 hands carefully selected so there are no blocker effects:

Hero: IP with a range of A♣A♦, K♣K♦, Q♣Q♦, J♣J♦, T♣T♦, 9♣9♦, 8♣8♦, 7♣7♦, 6♣6♦, 5♣5♦
Villain: OOP with a range of A♠A♥, K♠K♥, Q♠Q♥, J♠J♥, T♠T♥, 9♠9♥, 8♠8♥, 7♠7♥, 6♠6♥, 5♠5♥
The board: 2♥2♠2♦3♠3♥ so there is no interference with the ranges.
Stack depth: 2x Pot

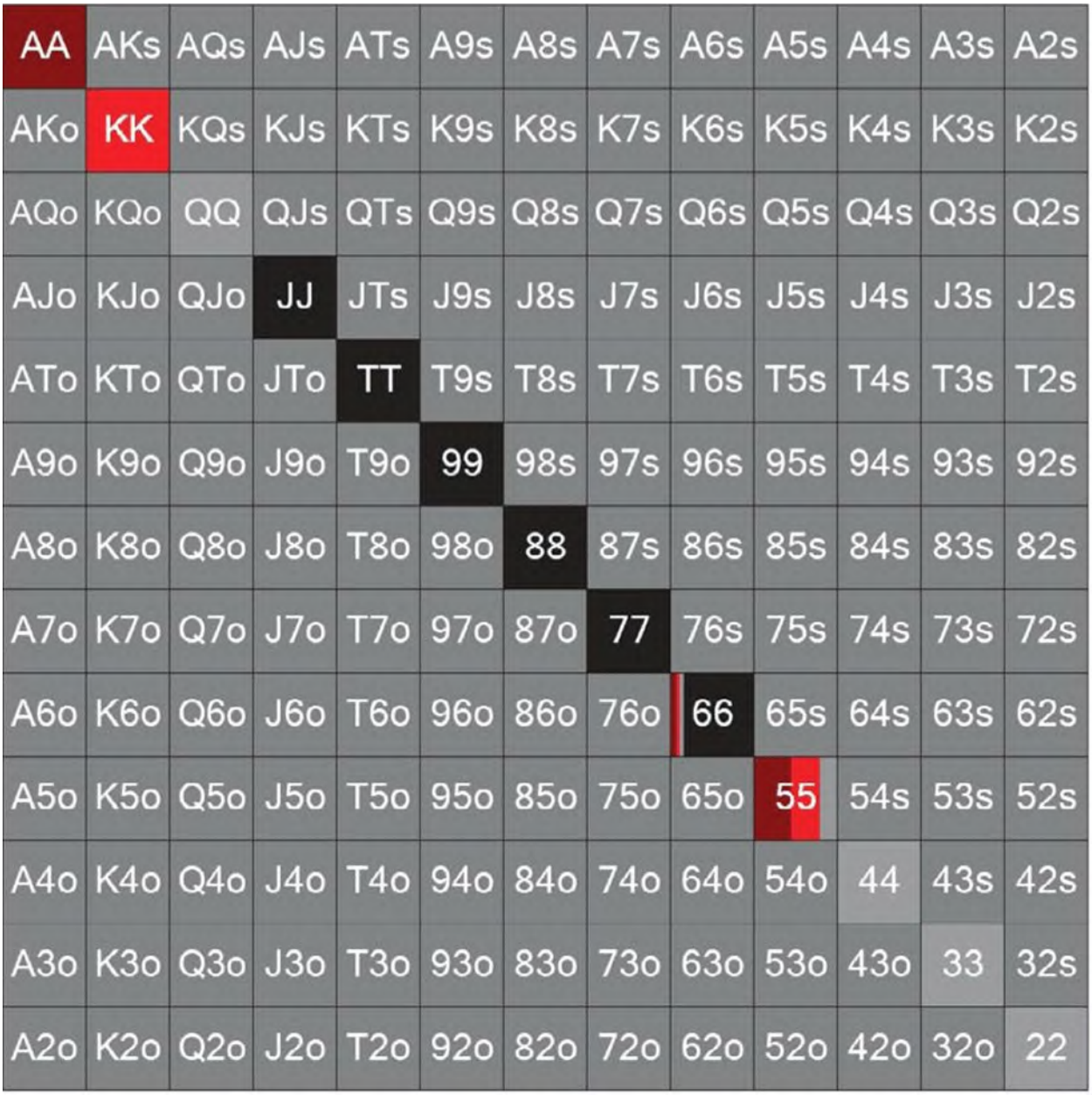
Bet-sizes: full pot, 2/3-pot and 1/3-pot.

In this experiment we get the same results as the [0-1] Toy Game predicts with Hero's strongest hand AA using the biggest bet-size, KK using the second biggest bet-size and finally QQ using the smallest bet-size and balancing it out with 55, and 66 using all three-bet-sizes (the fraction of 55 in the range is not enough to make up all the bluffing frequency so a small portion of 66 is used to make up the difference). JJ-77 are always checked.

The Villain's response in this toy game is to always call AA against all bet-sizes, then add enough of all other hands to make IP bluffs indifferent to a bet or check.

[0-1] Toy Game Example A

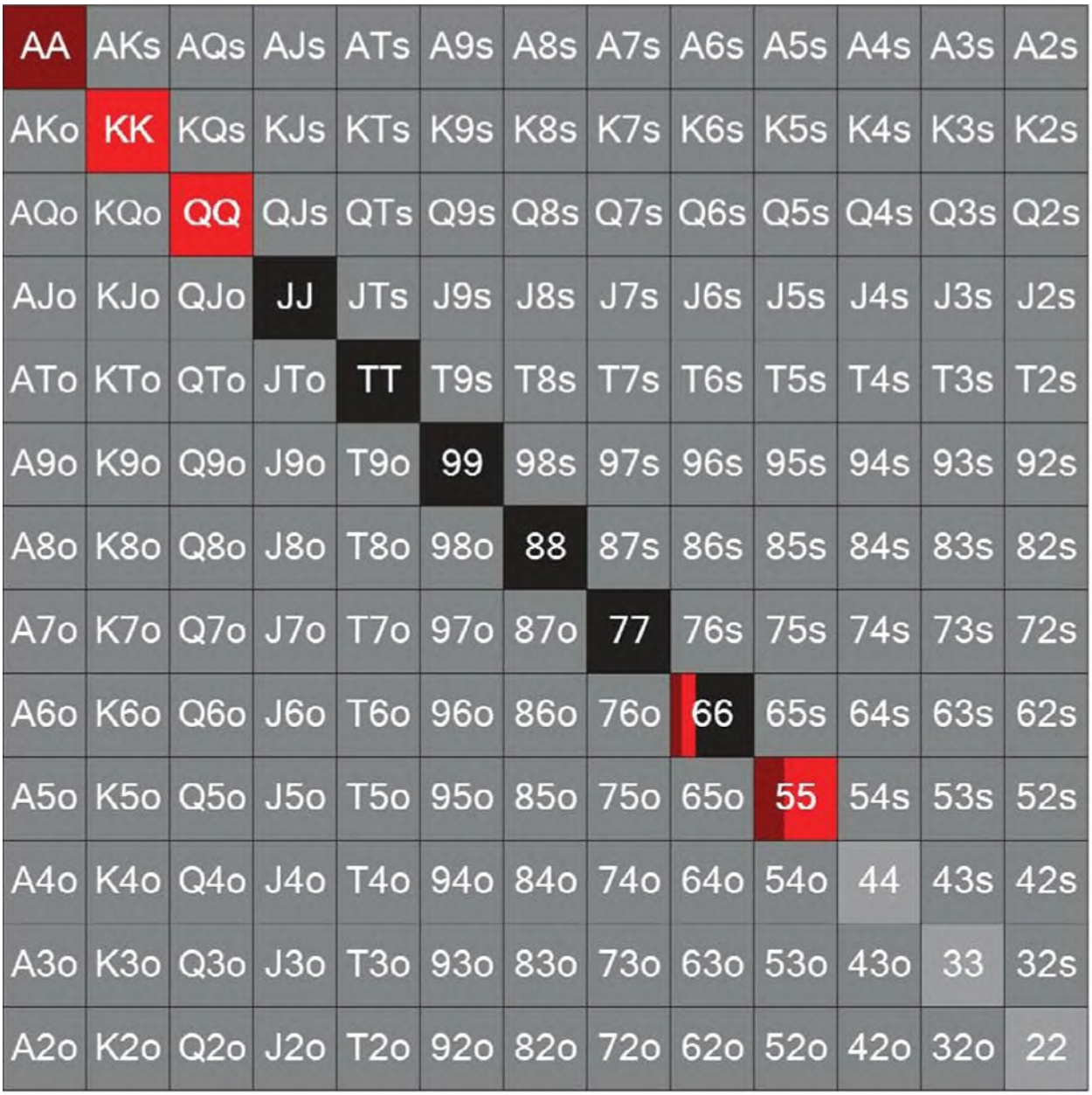
However, this toy game has some limitations that real poker does not have. For example, in real poker, your opponents can raise your bets so, if you use the 1/3-pot bet-size, they will know you can only have QQ or 55 and use that information to attack your capped range by raising with a range that is polarized against that distribution, for example AA, KK and some bluffs. This will allow the Villains to pick up extra EV *(Hand Range 337)*.



Hand Range 337: No x/r allowed • Bet Full Pot 15% / • Bet 2/3 Pot 14% / • Bet 1/3 Pot 15%/ • Check 56%

[0-1] Toy Game Example B

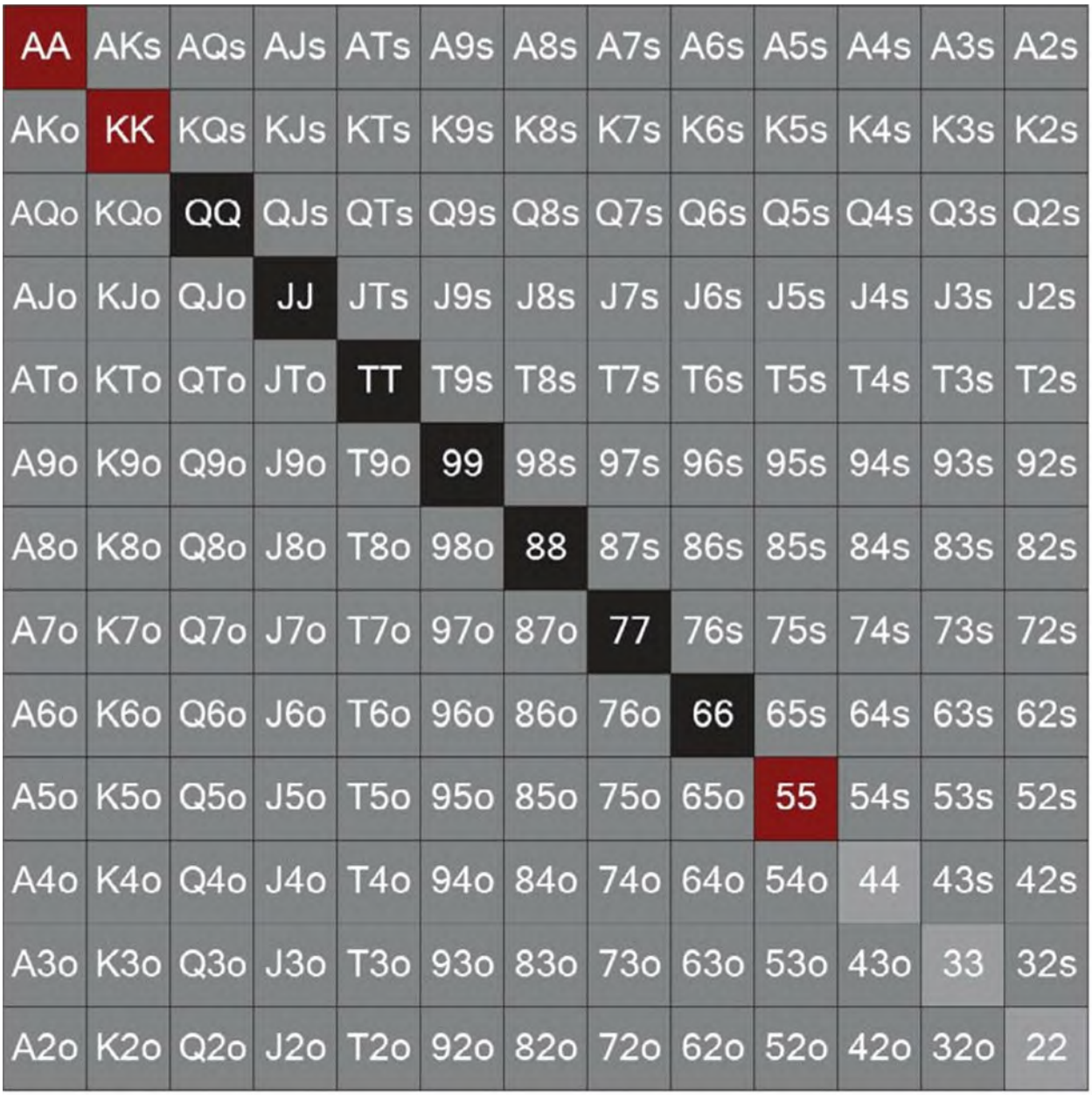
If the Villain is allowed to x/r against the 1/3-pot bet-size, they can leverage the information Hero is giving to take advantage of Hero's range construction. So, Hero immediately adjusts to never use that bet-size and QQ will shift entirely to the 2/3-pot bet-size *(Hand Range 338)*.



Hand Range 338: OOP x/r vs the 1/3 Bet-size • Bet Full Pot 15% / • Bet 2/3 Pot 28% / • Bet 1/3 Pot 0%/ • Check 57%

[0-1] Toy Game Example C

If we allow a x/r against all three different bet-sizes, Hero is no longer able to split their range into multiple bet-sizes and will adjust to only use the full pot-size bet, shrinking the value range to KK+ and checking back QQ-66 *(Hand Range 339)*.



Hand Range 339: OOP x/r allowed vs all bet-sizes • Bet Full Pot 30% / • Bet 2/3 Pot 0% / • Bet 1/3 Pot 0%/ • Check 70%

[0-1] Toy Game Example D

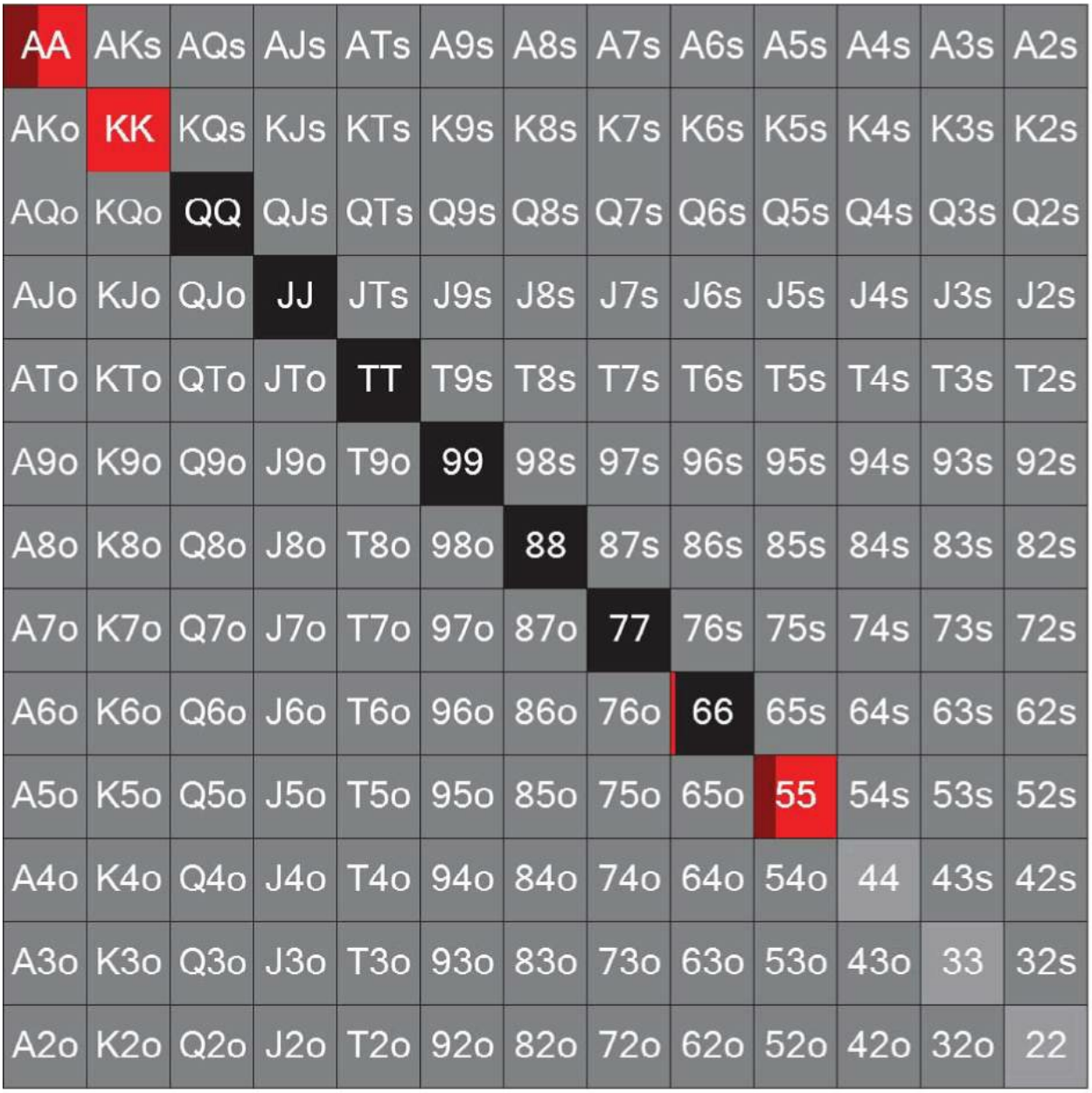
If we give Hero the option to go all-in and to additionally bet pot while the Villain is allowed to x/r, Hero will indeed split their range into the two bet-sizes:

♦ The all-in bet-size is used by AA 42% of the time and balanced by bluffing with 55 26%

of the time.

♦ The full pot bet-size is used by KK 100% of the time and is balanced with AA 58% of the time, which gives IP protection from OOP x/r and with 55 74% of the time as a bluff.

All-in is a special bet-size because it limits the Villain's options to only call and fold. At this 2x pot stack depth, OOP cannot effectively use the information given by Hero for exploitation.



Hand Range 340: IP All-in allowed (2x Pot) • Bet All-in 7% / • Bet Pot 24% / • Check 69%

If we increase the SPR to 3, Hero never goes all-in and reverts back to using only the full pot bet-size. With an SPR of 3, bluffing with 55 starts to become too expensive as OOP's range is strong enough to defend effectively *(Hand Range 340)*.

Summary

Toy Game	Description	IP EV
A	no x/r	56.11
B	x/r vs 1/3	54.98
C	x/r vs all sizes	54.96
D (SPR 2)	IP all-in allowed (2x Pot)	55.06
D (SPR 4)	IP all-in allowed (4x Pot)	55
Single Bet 1/3	IP Single bet size 1/3	53.27
Single Bet Pot	IP Single bet size Full Pot	55

Table 89: Summary of Toy Game Outcomes

In Toy Game A, when the Villain is not allowed to x/r, Hero can split the betting range between three different bet-sizes which allows capture of 56.11% of the pot.

In Toy Game B if we allow the Villain to x/r only against the 1/3-pot bet-size, Hero's response is to stop using that bet-size and their EV will reduce to 54.98%. If we lock Hero's strategy in Toy Game B to force the use of the 1/3-pot bet-size, even though it can be exploited by the Villain's x/r, Hero's EV reduces to 54%.

In Toy Game C, Hero reverts to a single bet-size due to exploitation by OOP x/r.

In Toy Game D, Hero's stack depth allows them to split their range into an all-in and pot-size bet when the SPR is 2, which grants a small EV gain for a total EV of 55.06%. However, Hero's EV is virtually the same as in toy game C which only uses the pot-size bet. If we increase the SPR to 4 in toy game D, Hero won't be using the all-in bet-size any more and chooses to use only the pot-size bet and there is no EV loss by restricting Hero to only the pot-size bet.

Limiting Hero to using only the pot-size bet retains EV, while limiting to the 1/3-pot size bet only reduces Hero's EV to 53.27%. So, choosing the wrong bet-size loses EV.

SPR Effect

Testing various SPR results on Hero's strategy shows a preference for the following bet-sizes *(Table 90)*.

SPR	Check	Bet 75%	Bet 100%	Bet 125%	Bet 150%	Bet 200%
10	70.0%	16.8%			13.2%	
5	70.0%	16.6%			13.5%	
3	70.0%	12.3%		17.7%		
2	69.3%	0.0%	24.2%	0.0%	0.0%	6.5%
1.5	69.0%		15.0%		16.0%	
1	70.0%		30.0%			
0.75	66.6%	33.4%				

Table 90: [0-1] Single Street Toy Game Optimal Bet Sizes (Shaded boxes are all-in bets)

♦ If the SPR is 1 or less, the optimal bet-size is in fact all-in.

♦ For SPR 1-2 the range gets split between pot and all-in.

♦ For SPR 3 the all-in bet stops being used and the betting range gets split between 75% pot and 125% pot

♦ For SPR 5 to 10 the betting range gets split between 75% pot and 150% pot.

If we simplify Hero's strategy in the [0-1] Single Street Toy Game by removing the least frequently used bet-size from the game tree across all SPRs, leaving Hero with a single bet-size option, the EV loss diminshes as the SPR decreases and the average EV loss across all SPRs is 0.21% of the pot *(Table 91)*.

SPR	Two Bet Sizes Hero EV	Single Bet Size Hero EV	Ev Diff
10	55.06%	54.73%	0.33%
5	55.06%	54.72%	0.34%
3	55.09%	54.90%	0.19%
2	55.06%	55.00%	0.06%
1.5	55.34%	55.20%	0.14%
Average	55.12%	54.91%	0.21%

Table 91: Comparing Single and Two Bet-sizes for Hero

Conclusion

Using multiple bet-sizes is dangerous and it's more dangerous in the early betting rounds. Splitting your range into different bet-sizes gives away information that your opponents could leverage against you when they have the option to raise or bet. This effect gets magnified when betting happens across multiple streets. The way ranges interact with the board and cards to come shift equities, as is the case of real poker. When the board runout can change the hand's value and there are possible blocker effects by the board or Villain's hands blocking value hands or bluffs, fewer bet-sizes should be used.

For this reason we don't have to worry about optimal play containing infinite bet-sizes because there is always going to be a tradeoff between the possible EV gained by using the perfect bet-size with a specific portion of your range and how much you lose by giving your opponents additional information about your holdings.

Even if GTO solvers can manage to split and balance out multiple bet-sizes the EV gained by doing so is not, in most cases, substantial enough to warrant the increased difficulty for a human player to implement them.

I tested many different bet-sizes on thousands of post-flop GTO simulations across all 1,755 flops and found that most flops will have one or two dominant bet-sizes. If the bet-sizes are close to each other, for example 25% pot or 33% pot, they will have virtually identical EVs, making the solver indifferent between them. If the solver splits a player's range evenly between two similar bet-sizes, the game tree can be simplified by removing the lower frequency bet-size and keeping only the higher frequency bet-size with no EV loss because most of the time the EV difference is within the Nash distance. The same thing can be done if one bet-size is very dominant and the solver chooses several other bet-sizes infrequently. The low frequency bet-sizes can be removed from the game tree and the new strategy that only uses the higher frequency bet-size will preserve the EV. Finally, if the solver splits its range between two bet-sizes that are very far apart, both bet-sizes can be replaced by another bet-size that is in the middle.

Simplifying a strategy by removing the smaller bet-sizes and leaving only large ones typically lowers the player's overall betting frequency as many hands that are profitable bets with the smaller bet-size might no longer be profitable bets with the larger bet-size. Conversely, removing the large bet-sizes from the simulation leaves only small ones, which generally boosts the player's betting frequency.

> *Both theory and practice agree with the premise that splitting your range into multiple bet-sizes does not add substantial EV to your strategy against a GTO opponent who can react properly. However, changing your bet-size exploitatively with different parts of your range against a player you think will be prone to making mistakes can be extremely*

profitable.

Optimal Bet-size

Is there an optimal bet-size that will always maximize your EV?

Bet-sizing is affected by the range's polarization and the number of streets left to play. Earlier in Chapter 2, we went over the Clairvoyance Single Street Toy Game that shows how, with a purely polarized range vs a bluff-catcher range, the optimal bet-size is to bet all of your chips, and the optimal bet-size for the player with the depolarized range is to bet 0 chips (always check).

In the [0-1] Single Street Toy game, we saw that the optimal bet-size when the players' ranges are symmetrical was to bet big but since both players have the exact same range there is a cap as to how big the bets can be and that cap depends on the SPR. But NLH is played across multiple streets, so how would playing across multiple streets affect the play in these toy games?

Geometrical Bet-sizing

The optimal bet-size that maximizes EV for the player with the polarized range on the multi-street version of the Clairvoyance Toy game is given by the geometrical growth of the pot. This implies a betting structure where the same fraction of the pot is bet on each street so that the river bet is always all-in.

The general formula to find the final pot size after a number of betting streets is given by:

$$FP = (SP) * (R)^S$$

Where:
FP = Final Pot Size
SP = Starting Pot Size
R = Pot Growth Rate
S = Number of Betting Streets

Which can be rearranged to find the Pot growth rate (R) that can later be used to find the Geometrical Bet-size. (The proof of this concept goes beyond the scope of this text. If you want to expand on it you can find more details in *The Mathematics of Poker* by Bill Chen and Jerrod Ankenman.)

$$R = \left(\frac{FP}{SP}\right)^{\frac{1}{S}}$$

Example

Game: Live Cash game

Stacks: Hero $1,900, Villain: $1,000

Players: 9

Blinds: $5/$10 (no ante)

Pre-flop: Action folds to Hero in the SB who raises to $35, the Villain in the BB calls, and we get to the flop. How much should Hero bet on each street if wanting to use the geometrical bet-size?

We need to figure out the pot growth rate (R). In this example the betting is calculated across three streets starting on the flop, so the starting pot is $70, the final pot size when both players are all-in will be $2,000 and the number of betting streets is 3.

First we calculate the pot growth rate (R):

$$R = \left(\frac{2000}{70}\right)^{\frac{1}{3}}$$

$$R = \left(\frac{200}{7}\right)^{\frac{1}{3}} = 3.06$$

Then the geometrical bet-size is given by:

$$(SP) + 2(Bet\ Size) = R * (SP)$$

$$2(Bet\ Size) = 3.06(SP) - (SP)$$

$$2(Bet\ Size) = 2.06(SP)$$

$$Bet\ Size = \frac{2.06}{2}(SP)$$

$$Bet\ Size = 1.03(SP)$$

If Hero wants to use the geometrical bet-size, it is necessary to slightly overbet the pot on each street:

$$Flop\ Bet\ Size = 1.03 * \$70 = \$72.1$$

$$Turn\ Bet\ Size = 1.03 * \$214.2 = \$220.63$$

$$River\ Bet\ Size = 1.03 * \$655.45 = \$675.12$$

It's important to notice that implementing the geometrical bet-size when stacks are very deep results in very large bets (often these are overbets). In real poker, the ranges will never be perfectly polarized and betting too large forces the Villain to fold the weaker portions of their range and only continue with the strongest hands. If you bet large enough to make the Villain only call when you are beat, you won't be able to value-bet any more because betting will lose you money. Thus, there is a cap to the bet-size Hero can use across multiple streets. Particularly when stacks are deep, this cap will be lower than the geometrical bet-size.

The geometrical bet-size only applies for situations when one player's range is perfectly polar

(made of hands with 100% equity and hands with 0% equity) and the other player's range is 100% bluff-catchers, which will never be the case in real poker. So, it is unlikely that the geometrical bet-size will be optimal for Hero, but it at least gives us a good general idea of what Hero's strategy should be when their range is polarized: big bets across multiple streets!

Range Polarization Effect

We now return to the [0-1] Single Street Toy Game with the following set up:

The board: 2♥2♠2♦2♣3♥
The SPR: 4
Bet-sizes: 30% Pot, 60% Pot, 90% Pot, 120% Pot, All-in
Hero: IP
Villain: OOP

In this toy game Villain always checks to Hero, but is allowed to raise if Hero bets. In this setup both players always have 50% equity.

[0-1] Toy Game A: Hero Has a Big Polarization Disadvantage
Hero's range is QQ, JJ, TT, 99, 88, 77, 66
Villain's range is AA, KK, QQ, JJ, TT, 99, 88, 77, 66, 55, 44

[0-1] Toy Game B: Hero Has a Slight Polarization Disadvantage
Hero's range is KK, QQ, JJ, TT, 99, 88, 77, 66, 55
Villain's range is AA, KK, QQ, JJ, TT, 99, 88, 77, 66, 55, 44

[0-1] Toy Game C: Symmetric Ranges
Hero's range is AA, KK, QQ, JJ, TT, 99, 88, 77, 66, 55, 44
Villain's range is AA, KK, QQ, JJ, TT, 99, 88, 77, 66, 55, 44

[0-1] Toy game D: Villain Has a Slight Polarization Disadvantage
Hero's range is AA, KK, QQ, JJ, TT, 99, 88, 77, 66, 55, 44
Villain's range is KK, QQ, JJ, TT, 99, 88, 77, 66, 55

[0-1] Toy game E: Villain Has a Big Polarization Disadvantage
Hero's range is AA, KK, QQ, JJ, TT, 99, 88, 77, 66, 55, 44

Villain's range is QQ, JJ, TT, 99, 88, 77, 66

Toy Game	Hero EV	All-in	Bet 120%	Bet 90%	Bet 60%	Bet 30%	Check %
A	50.00%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
B	50.16%	0.0%	0.1%	0.4%	14.7%	0.1%	84.7%
C	55.02%	0.1%	12.2%	13.8%	1.2%	0.0%	72.7%
D	62.16%	13.9%	14.5%	8.5%	5.9%	0.0%	57.1%
E	69.23%	32.7%	14.0%	0.1%	0.1%	0.1%	53.1%

Table 92: Hero Stats According to Range Polarization

Hero's EV increases as they gain the polarization advantage *(Table 92)*. The smaller size 30% Pot is never used and the bigger bet-sizes are increasingly used as Hero's range gains the polarization advantage.

- ♦ **Toy Game A (Hero's range is very depolarized):** The strategy is to always check and simply split the pot 50% of the time.
- ♦ **Toy Game B (Hero's range is slightly depolarized):** Hero can start betting ~15% of the time using the 60% bet-size with the bigger bet-sizes not being used.
- ♦ **Toy Game C (the ranges are symmetric):** Hero's range gets split among the bigger bet-sizes of 90% and 120% but all-in is still not used.
- ♦ **Toy game D (Hero starts to have a slight polarization advantage):** the all-in bet-size starts to get used, but the dominant bet-size is the 120% overbet.
- ♦ **Toy Game E (Hero has a large polarization advantage):** all-in becomes by far the dominant bet-size, with the small and medium bet-sizes never used.

If Hero's range becomes perfectly polarized and the Villain's becomes bluff -catchers only, the strategies will result in Hero only using the all-in bet-size.

Multi-street Betting

[0-1] Multi-street Toy Game
The board: 2♥2♠2♦2♣ (turn play)

The SPR: 4
Bet-sizes: 30% Pot, 60% Pot, 90% Pot, 120% Pot, All-in
Hero: IP
Villain: OOP

In this toy game Villain checks to Hero on the turn but is allowed to raise if Hero bets. Both players can bet, raise, call or fold on the river.

Using the same range distribution examples as in the Range Polarization Effect section, we get the following range polarization stats *(Table 93)*.

Toy Game	Hero EV	Hero Equity	All-in	Bet 120%	Bet 90%	Bet 60%	Bet 30%	Check %
A	28.89%	45.98%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
B	39.67%	47.77%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
C	52.87%	50.00%	0.0%	0.0%	0.1%	0.1%	35.1%	64.7%
D	67.94%	52.24%	0.0%	0.1%	0.8%	19.0%	53.3%	26.7%
E	81.33%	54.02%	0.0%	0.2%	8.8%	29.4%	52.4%	9.2%

Table 93: Hero Stats According to Range Polarization

In this set-up, Hero not only has the polarization advantage, but also has equity advantage, so the expectation is even bigger than in the single street toy game. Also, betting across multiple streets is always beneficial for the player with the polarized range.

In Toy Games A and B, Hero has the depolarized range. In the single street toy game Hero was still able to bet with a small frequency when we removed KK and 44 from their range. Here, however, in the multi-street version of the game, even a slight polarization disadvantage is enough to stop Hero from doing any betting at all. Despite having position, Hero chooses to never bet, as checking back effectively removes one betting street from the game tree, allowing Hero to get to the river with their full range. Meanwhile betting would result in Hero having to fold some hands to a x/r. Going all-in will not help Hero either because Villain's range is stronger than Hero's range and putting in very large bets with the weaker range is a losing proposition.

In Toy Game C, the ranges are symmetric and Hero starts using the smaller bet-size of 30% Pot for the first time. As Hero gets the polarization advantage, the overall betting frequency increases, and the bigger bet-sizes are implemented. With SPR 4, the geometrical bet-size with two betting streets is 100% pot, but the bet-sizes chosen by the solver are far smaller than that, so

Hero's range has to be even more polarized compared to the Villain for the bigger bet-sizes to become dominant.

In Toy Game E, Hero's strategy is to bet small on the turn with a high frequency, combining the polarized and depolarized portions of their range. This action is often referred to as *range merging*. The reason Hero chooses to bet a merged range instead of a polarized range is the Villain's ability to bet the river. If Hero polarizes their betting range too much on the turn, choosing big bet-sizes with the top and bottom of their range, opting to check back middling hands such as TT-88, then Villain has the option to bet the river and attack Hero's capped range and thus to increase expectation. By betting a merged range for a smaller bet-size on the turn, Hero gets to increase their betting frequency, minimizing the effect of checking back a weak capped range. Furthermore, after Villain has called the turn bet, Villain will mostly check to Hero who will then be able to check back middling strength hands, realizing their equity.

If we increase Hero's polarization advantage by shrinking the Villain's range to JJ-77 (Toy Game F), Hero will be able to bet 100% of their range on the turn. The 30% bet-size remains the highest frequency bet-size, but the middling 60% bet-size starts to disappear, while the 90% bet-size frequency increases and Hero even starts tapping into the 120% overbet *(Table 94)*.

Toy Game	Hero EV	Hero Equity	All-in	Bet 120%	Bet 90%	Bet 60%	Bet 30%	Check %
F	92.46%	55.37%	0.0%	10.5%	31.6%	1.3%	56.1%	0.5%

Table 94: Results of Toy Game F

Conclusion

The more polarized Hero's range is compared to Villain's range, the more they are incentivized to use bigger bet-sizes. If betting can happen across multiple streets, Hero is more likely to choose smaller bet-sizes on the early streets and choose to bet a merged range, waiting until future streets to start polarizing their betting range, unless they have a very substantial polarization advantage. In that case, their bet-size will approach the geometrical bet-size unless the SPR is very high because of the threat of the Villain's range containing traps, which reduces the profitability of making large bets. For this reason, all-in bets are rarely used on early streets unless stacks are shallow.

Bet-sizing Based on Runout

We already know that you don't need to split your range into different bet-sizes on the flop, but

should you have different bet-sizes for different flops?

Different flops will have a different effect on the ranges' equities and polarization. Our test with the [0-1] Toy Game proves that bet-size is affected by the range polarization and also that using the wrong bet-size can cost EV. This suggests that GTO play on different types of flops will involve the use of flop-specific bet-sizes.

To test this hypothesis I ran all 1,755 flops in a Single Raised Pot (SRP) BB vs BN scenario with 40bbs effective stacks. In one simulation I used four different bet-sizes: min-bets, 1/3-pot, 1/2-pot and 2/3-pot, and got IP average EV across all flops accounting for each flop's individual weight, in order to represent all 22,100 specific flops (accounting for suits). Then I re-ran the same scenario using only the 1/3-pot size. The results are summarized in *Table 95*.

Simulation	EV
4 Flop Cbet sizes	71.1278
1/3 Pot Only	70.9828
EV Difference	0.1450
EV loss in bb/100	0.8990

Table 95: Summary of Simulations with Varying Bet-sizes

The average EV difference across all flops is -0.14% of the pot, or 0.9 bb/100, when using a single bet-size compared to using four-bet-sizes. However, this test compares the single bet-size simulation to a simulation that has four-bet-sizes and can maximize the EV of each individual combo by choosing any of the four available bet-sizes. This is different than running each one of the 1,755 simulations using only the best of the four-bet-sizes for each flop. Still, if I had done that, the EV of using only the "optimal bet-size" among the four options cannot be higher than the EV of using 4 bet-sizes that maximized each combo's EV because if that is the case, the solver will only choose one of them even when having four options to choose from. At most, the EV of solving each flop with only one optimal bet-size has to be the same as the EV of a simulation that has all four-bet-sizes.

Assuming perfect play from each player, the average EV loss using only the 1/3-pot size in the tested set up is at most 0.9bb/100. This number could change with different stack depths and different ranges, but it gives us a reasonable starting point, since this is the average across all 1,755 flops. It is not the same as if it was -0.9bb/100 lost on a single flop, so this number is very significant. However, it assumes perfect play from both players and we know that is far away from real poker, as both Hero and Villain will make mistakes.

Some people advocate for oversimplifying their strategies with a "single bet-size fits all"

approach based on the premise that adjusting the bet-size according to the flop is not worth the hassle, given the small, if any, EV to be gained when compared to using a reasonable bet-size across all 1,755 flops. While I understand this reasoning, I don't agree with the "single bet-size fits all" approach. Yes, there might not be too much EV to be won against a GTO player when changing your bet-size on different flops. However, you won't be playing against a GTO player. Putting in the extra effort to understand how some flops are different to others and what bet-size to use makes more sense. Given the way ranges interact with the board will not only make your hand easier to play, but it will also make life more difficult for your opponents who might not be used to facing different bet-sizes. Even if the GTO player could defend with the exact calling, folding and raising frequencies to make your bet-sizes indifferent or just slightly better than the "standard" bet-size, that might not be the case for your human opponents who could struggle to defend against non-standard lines. You won't have that problem. If your opponent uses the GTO bet-size or close to it against you, you have a very good idea of how to defend. If your opponent uses a non-GTO bet-size, then you can try to exploit this suboptimal bet-size selection.

Example

You are in the BB with a 30bb effective stack, UTG min-raises, the action folds to you and you call. The flop comes J♠2♥2♦ and you check.

On a paired flop such as J22, UTG's GTO play when checked to is to min-bet the flop 100% of the time and this will generate an EV of 77.05. If your opponent instead makes a 2/3-pot bet, they can no longer continuation bet their entire range, because if they do, then you will be able to exploit them by switching to a x/r only strategy which will make the Villain's EV diminish to 71.01. If they are a good player and lower their C-bet frequency to match the new equilibrium, they should be c-betting the flop 42.45% of the time and their EV will be 74.10. If this player is good enough to know what a good 1/3-pot GTO c-betting strategy looks like from UTG vs BB on J22, why are they using a suboptimal strategy that loses EV instead of simply going for the GTO line? Chances are they are not c-betting at a GTO frequency for that bet-size and their range is probably going to be highly unbalanced, so there might be even more room for exploitation.

> *To make money playing poker, you don't need to play perfect GTO in every single line and to know the absolute optimal bet-size on any given flop because your opponents are not playing perfect GTO themselves. All you have to do is make, on average, better decisions than them, enough to create a solid win rate, and keep improving so they don't catch up to you.*

Most of the time the solver is indifferent to similar bet-sizes. For example, there probably isn't too much difference between betting 25% or 33% Pot, or 60% or 67% Pot. Most of the time it is good enough to know if the flop is a "big bet-size" flop or "small bet-size" flop. For MTTs, I recommend using two c-bet sizes: 1/3-pot, and 2/3-pot. If you want to play a more complex strategy, you could add min-bets and 120% overbets to the mix. If you want to simplify your strategy to only one bet-size, you could opt for the 1/3-pot across the board, which is in fact what most online MTT regulars are doing in modern games. This strategy works fine against the population as it simplifies the game tree, is really easy to implement, and it allows you to c-bet at a high frequency on most boards. This forces Villains into making a decision, revealing information about their range at a low cost. It also exploits population tendencies, as most people still overfold to small bets.

My recommendation is to become proficient with at least a couple bet-sizes (a big one and a small one), and to understand how to implement them correctly. They you have a solid strategy you can play against tough opponents to keep them guessing while also being able to defend well when they are the ones using non-standard lines. Against weaker players, you can mix it up and play an exploitative strategy. Don't be afraid of being counter-exploited when playing against unaware opponents because even if they knew what you are doing, chances are they won't know how to properly adjust to counter you. Keep hammering on them until they start fighting back. If you think you can get away with c-betting at a higher frequency than optimal against a Villain or manipulate them into folding or calling with your bet-size, then go for it! Always be aware and mindful of the situation you are in.

Bet-sizing and Modern Solvers

Modern GTO solvers can be set up to solve for a specific spot with several bet-sizes, but it is up to the user to input those bet-sizes. A GTO solver cannot figure out the optimal bet-sizes by itself and build the game tree for us. That job is left to the user, so it is up to us to use our knowledge and expertise as poker players to input bet-sizes that we think are a good representation of the situation we want to model and solve the game tree within those parameters.

When you choose the bet-sizes a player can use in any given spot, you are limiting their actions to only those options. For example, if you input flop bet-sizes of 1/2-pot and 2/3-pot, those are the only bet-sizes the player can use on the flop. As another example, if you don't give the OOP player the option to x/r the flop, if they can only call or fold, that will have an effect on IP Betting strategy as IP now knows there is a 0% chance OOP will x/r the flop. IP is now incentivized to bet at a higher frequency because their equity in the pot cannot be denied. For this

reason it is important to make sure all the players in the GTO simulation have proper bet-sizes and can react effectively to most lines so that the solver's output is not skewed as a result of a bad betting structure affecting one of the players in a given line – unless you are actively trying to exploit a player's known leak.

It can be tempting to use as many bet-sizes as you can in GTO calculations but, unfortunately, using too many bet-sizes is impractical as each bet-size added increases the game tree size exponentially. This makes it almost impossible for a human to correctly implement all of them in game. Furthermore, bigger game trees increase the computational power and time required for the GTO solver to finish the simulations which also makes the use of too many bet-sizes impractical.

We are faced with the dilemma of making the game trees as accurate as possible to represent a wide range of possibilities while at the same time trying to make the size of the GTO simulations manageable and the strategies simple enough to be implemented in game. Fortunately, we don't really need to test for all possible bet-sizes, as trying something like the square root of Pi would be absurd. Most poker players bet a fraction of the pot, so bet-sizes such as 1/2-pot and 2/3-pot are reasonable approximations. Testing for common bet-sizes and finding the ones the solver typically likes the most could help us develop strategies that can be easily implemented while remaining relevant to our own games.

Sometimes the solver will show a clear preference for taking an action with a hand because the EV for that action is clearly higher than the EV of taking any other action. Many times the EV reported by the solver for individual combos will be virtually identical for different actions, such as betting or checking and this can make players think that it doesn't matter how to play post-flop because everything is indifferent. This is a huge mistake. The EVs reported by the solver assume both players are playing at equilibrium. If we start changing the frequencies of the hands to a point where the overall strategy and range composition is no longer the same, the ranges become exploitable and the EV is no longer guaranteed, as the Villain would be able to adjust their strategy.

Imagine a hypothetical situation where the GTO strategy is betting all hands in the range with a 50% frequency. In this situation, you would be indifferent to betting or checking each combo. If you take the top strongest half of the range and bet it at a 100% frequency and check the weaker half 100%, your overall bet/check frequency would be the same but clearly the new strategy will be a lot more exploitable than GTO. An aware opponent could start to fold more often when you bet and attack your checks by playing very aggressively. Of course, it is impossible to play all combos in the exact GTO frequencies, but it is important to try to keep the ranges reasonably balanced and maintain board coverage. If the changes are too drastic, they won't go unnoticed, so before making any big changes to the GTO strategies, thinking it doesn't

matter, first lock the new strategy in the solver and re-run it. See if there is any substantial EV loss when playing against a min-exploitative opponent before implementing them in your games.

It is vitally important to remember that the indifference between two or more actions is created by your opponent's play. If they are not aware that their strategies are fundamentally flawed and unbalanced, then a seemingly close spot becomes more binary and against that particular Villain, one given action will always yield a higher expectation than any other.

11

THE THEORY OF FLOP PLAY

So, you've put in the effort into understanding pre-flop play and have a good idea of what player's ranges look like in general. The three board cards are dealt and you ask yourself, what now? Well, in this section we will study the different flop types, how the different flops interact with the players' ranges, and what the effects of these interactions in post-flop betting strategies are.

Suit Isomorphism

Isomorphism is a general concept that appears in several areas of mathematics. The word derives from the Greek *iso*, meaning *"equal"*, and *morphosis*, meaning *"to form"* or *"to shape"*. Two or more objects are isomorphic if they cannot be distinguished from one another by using only a specified set of properties.

As we saw in Chapter 1, by representing hands such as A♠K♠, A♥K♥, A♣K♣, A♦K♦ in the same square of a 13×13 grid as AKs, and repeating the same process to all other suited hands, pocket pairs and offsuit hands, we can effectively reduce the 1,326 combos into 169 Poker hands. This is possible because suits only become relevant post-flop when they interact with the community cards, and pre-flop no suit is better or worse than any other suit (they are strategically equivalent – in other words, isomorphic).

Based on the previous premise, there is no reason for a player to have any particular suit in their range more frequently than any other. So, suit isomorphism can also be applied to the 22,100 specific flops, effectively reducing the game to 1,755 strategically unique flops.

The four flops A♠K♠Q♠, A♥K♥Q♥, A♣K♣Q♣, and A♦K♦Q♦ can be studied as if they were the exact same flop because on each of them, any given range will always have the exact same number of flopped flushes, flush draws, sets, top pair, etc, and a hand like a flush will always be played the same regardless of the suit. For example J♠T♠ on A♠K♠Q♠ will be played exactly as J♥T♥ on A♥K♥Q♥.

There are two main reasons why we would want to reduce the size of the game. The first is that, as humans, it is easier to "learn" strategies for only 1,755 flops rather than 22,100. The second is for saving server time in solver calculations. Instead of calculating redundant flops over and over again, we can run only one of each type of isomorphic flop and extrapolate from the results.

Dynamic and Static Boards

The concept of Flop Volatility was first introduced by Will Tipton in his excellent book *Expert Heads Up No Limit Hold'em, Volume1: Optimal and Exploitative Strategies* (D&B Publishing).

> *"So, the second important texture-related property of a flop is how likely future cards are to change the relative values of players' hands. This likelihood is a property of the flop in combination with players' ranges. We will call boards on which hands are very likely to change in value by the river 'volatile'. Boards on which good hands are likely to stay good and bad hands likely to stay bad are called 'static'."*

In essence volatile (or dynamic) boards are those in which the player's hand equities can shift drastically in value on future streets, and static boards are those in which the hand equities tend to remain relatively constant on most runouts. Low and connected boards with possible flush and straight draws are very dynamic, and offsuit disconnected flops with high cards tend to be static.

For example, in a typical BB vs EP single raised pot, the flop 8♥7♥3♦ would be a dynamic board because there are many cards that can come and promote or demote the hand values in both players' ranges. Any heart will complete a flush, and any 5, 6, 9, T or J can complete a straight. Also, any turn or river card higher than an 8 can make a random hand improve to a higher pair than the flopped top pair, while on a flop like K♠7♦2♥, the hand's value will remain relatively constant on most turns and rivers.

Flop Classification Scheme

A lot of poker players never study the game. They learn by playing, and this is probably the best thing to do when you are first getting into poker. However, soon you will realize that, given the immense number of different situations that can occur, even if all you did was to play poker 24/7 for years, it is impossible to learn everything there is to learn by just playing. Many players understand this and they take the next step by getting professional coaching, but even the best coaches won't be available 24/7 to answer all your questions. Even if that was the case, they surely won't always have the right answer to every single spot. For this reason, people have tried to develop assisting software for years. It has already happened in games such as chess, where players can access top engines from their computers and even smartphones to get an immediate answer to what the correct play is in any given chess position.

In modern poker we have access to GTO solvers and, just as in chess, we now can get almost immediate answers as to how to play any spot at any given time. But again, we are faced with the issue of there being way too many spots to actually study each one of them. There are as many as 1,755 unique flops for any given spot, so this methodology is highly inefficient and would take an enormous amount of time. Thus the need for a better system.

Classification is the process of grouping things based on their similarities to make them easier to identify or study. Flops that share common characteristics tend to be played in a similar fashion. In this section, I describe a full comprehensive flop classification scheme, effectively dividing the problem into smaller, easier-to-solve pieces while at the same time keeping an eye on the game as a whole.

Flop Structure

The flop structure is the first thing to look at when the board is dealt. There are three possible flop structures, and post-flop play will accordingly vary completely.

- **Trips:** A trips flop is a flop that contains all cards of the same rank. For example: A♥A♣A♠, 7♥7♠7♦ or 3♣3♠ 3♦.
- **Paired:** A flop is paired if it contains two cards of the same rank. A paired flop can be paired rainbow, for example K♥K♣5♠ or paired two-tone, for example Q♦8♦8♣.
- **Unpaired:** A flop is unpaired if all the cards have different ranks, for example: Q♥7♦4♣ or A♥K♥Q♠.

Flop Textures

Flop texture is also important and can take three forms.

- **Monotone:** A monotone flop is a flop that contains all cards of a single suit, for example A♥K♥T♥ or J♠6♠5♠.
- **Two-tone:** A two-tone flop is a flop that contains two cards of a single suit and a third card of another suit. There are three subtypes of two-tone flops. If the top and medium card are suited, the flop is said to be two-tone high-mid, for example A♥K♥Q♠. If the medium and low cards are suited, the flop is said to be two-tone mid-low, for example J♥6♠5♠. If the high and low cards are suited, the flop is said to be two-tone high-low, for example A♥9♠2♥.
- **Rainbow:** A rainbow flop is a flop that contains all three cards of different suits, for example Q♥9♠7♦, 6♦4♣2♠ or K♣J♦7♥.

Flop Texture	Variants	Distinct Flops	Full Game	% of Total
Monotone	4	286	1,144	5.18%
Two Tone	12	858	10,296	46.59%
Rainbow	24	286	6,864	31.06%
Paired Rainbow	12	156	1,872	8.47%
Paired Two Tone	12	156	1,872	8.47%
Trips	4	13	52	0.24%
Total		1755	22100	100.00%

Table 96: All Possible Flops Categorized by Structure and Texture

Flop Rank

The flop rank will depend on its highest card. For example, Kxx represents all flops that contain a king and two other cards that are a king or lower *(Table 97)*.

As we can see, the higher the rank of the flop, the more flops of that rank exist. A-high boards are the most common, with 21.74% of all flops being Axx. Notice how 85% of all flops are rank 9 or higher while the remaining 15% flops are rank 8 or lower.

Flopped Straights

Flops can also be categorized by the number of possible flopped straights *(Table 98)*. For example, on the flop AQ7 there are zero possible flopped straights. On KT9 there is one possible flopped straight (with QJ). On 875 there are two possible flopped straights (96 and 64). Finally, on JT9 there are three possible flopped straights (KQ, Q8 and 87).

Flop Rank	Total Flops	% of Total
Axx	4,804	21.74%
Kxx	4,052	18.33%
Qxx	3,364	15.22%
Jxx	2,740	12.40%
Txx	2,180	9.86%
9xx	1,684	7.62%
8xx	1,252	5.67%
7xx	884	4.00%
6xx	580	2.62%
5xx	340	1.54%
4xx	164	0.74%
3xx	52	0.24%
222	4	0.02%
Total	22,100	100.00%

Table 97: All Possible Flops Categorized by Rank

Straights	Total Flops	% of Total	Description
3	512	2%	Three consecutive cards with no gaps in between except KQJ and 432
2	1,280	6%	Three consecutive cards with one gap in between plus KQJ and 432
1	2,304	10%	Three consecutive cards with two gaps in between
0	18,004	81%	Any trips, paired flop, or flops with more than two gaps in between
Total	22,100	100%	

Table 98: All Possible Flops Categorized by Possible Flopped Straights

Flops that have zero flopped straights can also be subcategorized according to the number of possible OESDs, but for the scope of this book we will only focus on the number of straights.

Flop Families

Some flops can be grouped together into families and subfamilies according to their rank. For example, the flops A54, A53, A52, A43, A42 and A32 are so similar that in many situations, they can be treated as the exact same flop: *Ace with two low cards.*

First let's group all the cards according to their rank:

High Card (H): Any card K, Q, J, T
Mid Card (M): Any card 9, 8, 7, 6
Low Card (L): Any card 5, 4, 3, 2
Ace (A): The lonely A

Now the flops can be categorized using the card ranks as follows *(Table 99)*.

Flop Family	Distinct Flops	Full Game
AAA	1	4
AAH	8	96
AAM	8	96
AAL	8	96
AHH	38	480
AHM	80	1,024
AHL	80	1,024
AMM	38	480
AML	80	1,024
ALL	38	480
HHH	48	560
HHM	152	1,920
HHL	152	1,920
HMM	152	1,920
HML	320	4,096
HLL	152	1,920
MMM	48	560
MML	152	1,920
MLL	152	1,920
LLL	48	560
Total	1,755	22,100

Table 99: All Possible Flops Categorized by Card Rank

Flop Subsets

As often mentioned previously, there are 22,100 possible flops in hold'em and, using suit isomorphism, we can reduce that number to 1,755 strategically different flops. For practical purposes, this number is still very large. For this reason, poker players, as well as programmers and theorists, have attempted to simplify the game by creating smaller flop subsets that accurately represent the whole game.

The first publicly known attempt to develop a subset of flops was performed by the poker

theorist Will Tipton. His methodology consisted of first creating conditions a good subset must satisfy and then finding the minimum subset of flops that satisfies all of them.

Tipton's proposed subset conditions:

♦ Any particular single card comes

♦ A flush draw of a particular suit comes

♦ A monotone flop of a particular suit comes

♦ A paired board with the pair being of a particular rank comes

♦ A three-straight board of any rank comes

♦ A board with any particular one-gap in the rank comes

♦ A board with any particular two-gap in the rank comes

Tipton's flop subset contains 103 flops but, unfortunately, it has some issues and cannot be used to fully represent the entire game. His methodology makes sense and was improved upon by others, but I found that it is simply too difficult to significantly reduce the game size while keeping an eye on all of its characteristics. I also tried a different approach, by selecting a flop representative of the different structures, textures, ranks, families and number of possible straights, and the lowest number of flop subsets I could create was 356 flops.

PioSOLVER developers Kuba and Piotr created a different methodology, consisting of defining some metrics which a good subset must satisfy, and then ran custom software to find the best subset of N elements that scores the best on the metrics. The metrics they used are equity against full range, against 50% range and against AA, as well as EVs from all 1,755 flops.

Kuba and Piotr tried several metrics and determined that a mix of EV and EQ performs better than others including EV alone. They developed subsets of different sizes, including 25, 49, 74, 95 and 184 flops. The more flops in the flop subset, the more accurate results you will get. This is particularly the case with high SPR, because of the different ways some elements of the range can hit some boards very strongly and create cooler situations that will end up with the players playing massive pots. For these situations to be accurately represented, you need to have as many flops as possible. You can find the subsets and more details on their blog at www.piosolver.com.

Their pre-flop subsets are optimized to accurately approximate equities and EV for the pre-flop solver, not post-flop strategies. For this reason, these subsets are not guaranteed to produce a good approximation of post-flop play. This is why I decided to go for a different approach and

simply use super-computers to solve the full game, all 1,755 flops in many different spots, and create custom software to analyze the data. This chapter was written using the results from this investigation. You can find more details of this work on www.gtopoker.io.

The Flop Donk Bet (DK)

A Villain who is IP (BN, CO, MP, EP), raises and the action folds around to Hero who is in the BB and makes a call. At this point you should have a pretty good idea about Villain's pre-flop range because of their position, stack depth and any tendencies you might have noticed. You also know what your own BB defending range looks like, what hands you would most likely be 3-betting pre-flop and what hands you are calling against this Villain in this particular situation. The flop is dealt and it is your time to act. Should you bet or check?

> *This is by far the most common situation in poker. Most poker hands will be played heads-up in a single raised pot between the BB and IP. Thus playing well post-flop after defending the blinds is of vital importance for any poker player's success.*

So, this will be the first post-flop situation we will study.

In this BB vs IP setup, the IP Player is commonly said to have the "betting lead" because they were the pre-flop aggressor. For this reason, IP is expected to continue the aggression on the flop by betting frequently when checked to. This type of bet performed by the previous street aggressor is known as a continuation bet (c-bet). Since IP is expected to c-bet the flop at a very high frequency, the BB is also expected to check to the pre-flop aggressor and never take the betting lead. When the player in the BB doesn't check and instead takes the lead by making a bet, the poker regulars would call this a donk bet, because it's a bet that goes against the norm. But does this general consensus of not taking the betting lead away from the pre-flop aggressor make sense conceptually from a game theory perspective?

First of all, in game theory there is no such a thing as the "betting lead", so taking the betting lead away from a player does not make sense in GTO. As we saw in the theory of betting, making a bet is a function of leveraging informational advantage, range composition and SPR with the objective of realizing your equity or preventing the opponent's equity realization. If we want to confirm or refute the general ideas about donk bets, we must do so through GTO principles.

I aggregated the data of GTO solutions across all possible flops in BB vs BN and BB vs UTG situations in single raised pots with stack depths 20bb, 30bb and 40bb. The BN and UTG were

used because they represent the widest and tightest ranges, while strategies from other positions will fall somewhere in between. The results show that the overall BB donk bet frequency is only 2% (for 1/4 and 2/3 bet-sizes) and the average IP c-betting frequency is 84%. The GTO simulations agree with the general consensus about donk betting not being widely used and c-bets being very common. However, if we look deeper into the data, there are some spots where the solver actually likes donk betting at a high frequency *(Table 100)*.

Player	Flop	Bet%	Check %	EQ	EV	EQR
BB	All Flops	2%	98%	40%	31	77%
IP	All Flops	84%	16%	60%	69	115%
BB	654r	67%	33%	51%	54	107%
IP	654r	46%	54%	49%	46	95%
BB	A76r	0.3%	99.7%	38%	24	63%
IP	A76r	99%	1%	62%	76	123%

Table 100: BB and IP stats (20bb/30bb/40bb)

On average, the highest frequency donk betting flop is 654r (67%), and one of the lowest donk betting flops is A76r (0.3%), Why is the BB betting frequency on A76r so low compared to 654r?

If betting was clearly the highest EV option for any hand in the BB range, the solver would always do it. If betting is indifferent to checking, then the hand will be played as a mixed strategy. If a hand is never being bet, it is because betting is lower EV compared to checking.

Returning to our EV equation:

$$Ev = [(Ev\ of\ Fold) * (\%\ Villain\ Folds\ )] + [(Ev\ Called) * (\%\ Villain\ Calls)] + [(Ev\ Reraised) * (\%\ Villain\ Raises)]$$

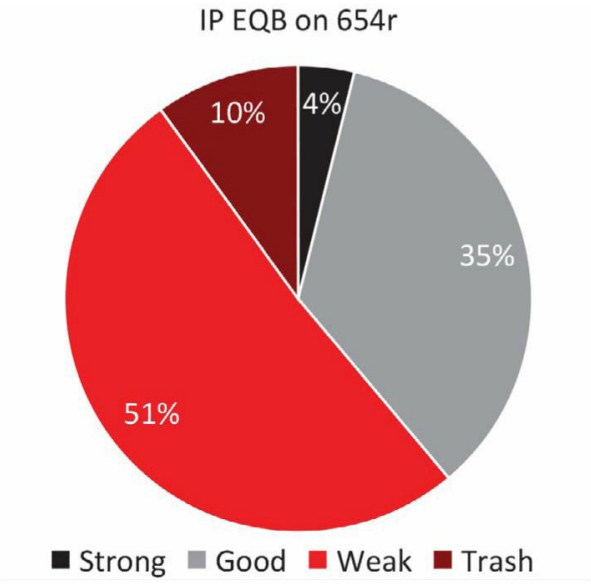
The EV of betting a hand depends on how often Villain folds, how often they raise, how often they call and the amount of equity Hero has when called. The stronger Villain's range, the less they will fold, the more often they will raise and the less equity Hero will have when called.

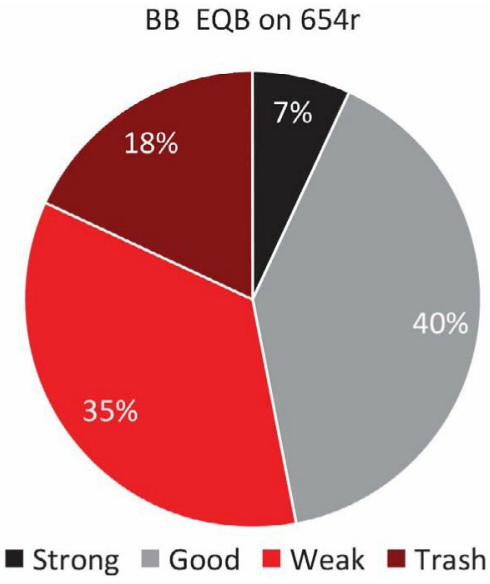
The GTO solver assumes play against a GTO opponent who knows your strategy and will call, raise and fold optimally against you. If IP's range is so strong that they won't be folding much vs a bet and, in contrast, will be able to raise a lot and call effectively, then betting becomes a lot less enticing than it would be against a weaker range distribution.

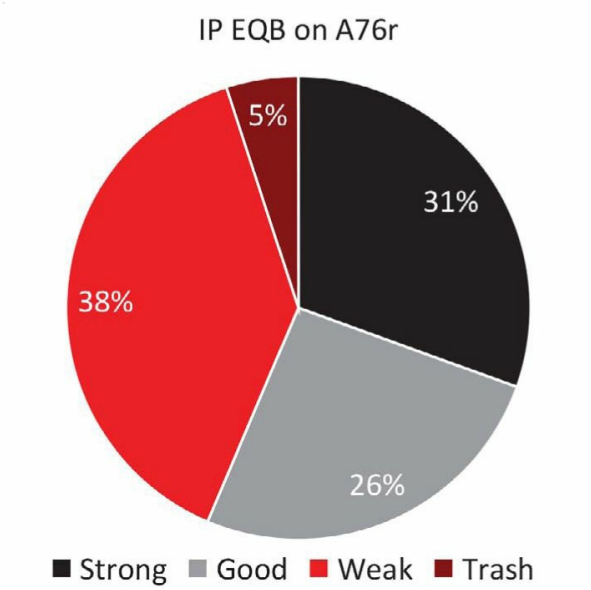
Clearly IP has the equity advantage with 62% equity vs the BB's 38% on A76r, which will of course reduce the profitability of the BB's bets, while on 654r, the BB has the equity advantage with 51% equity vs IP's 49%, making the BB's bets more profitable on this flop texture.

Range vs range equity is an important factor as it is difficult to develop betting strategies when having a substantial equity disadvantage. However, as we discussed in the theory of betting section, the range composition is even more important than raw equity.

Applying the concept of equity buckets that was introduced earlier, we can go beyond raw equity and get a better idea about the range distribution for both players across the different flops *(Diagram 25)*.







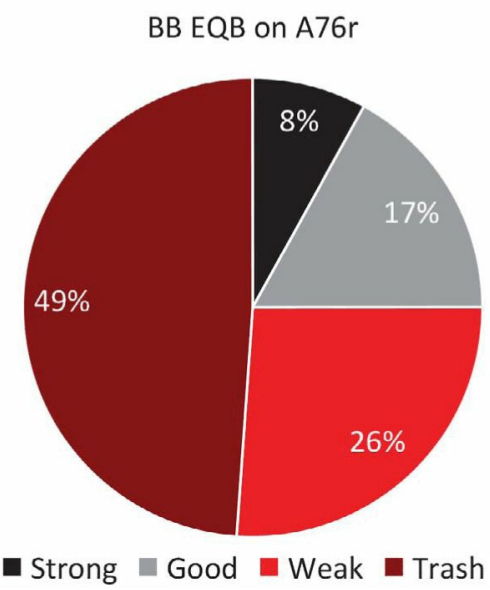


Diagram 25: Average BB vs IP Equity Buckets for 20bb/30bb/40bb Stacks

For the definition of strong, good, weak and trash hands, see the Equity Buckets section of Chapter 10.

On 654r, the BB has 7% strong hands, and IP has only 4%, while on A76r, the BB has 8% strong hands and IP has a staggering 31% strong hands! What happens is that, on A76r, IP's top pairs (any Ax) have on average 85% equity vs the BB's range, while a top pair on 654 will average about 65% equity. Additionally, on 654r, all of IP's Ax will have an average of 49% equity, effectively turning them into weak hands. On 654r, the BB's good hands increase from 17% to 40% and the trash hands reduce from 49% to 18% when compared to A76r.

Because of this distribution, the IP Player will be incentivized to lower the c-betting frequency on 654r, given that the bulk of their range are weak hands that don't perform well against a flop check/raise. So, by checking back more often, IP gets to see a free turn and realize equity. The BB reacts to this by donk betting many hands, forcing IP to either fold or put more money into the pot with the hands that would have been happy to check behind and see a free turn.

Donk betting makes sense on 654r because it denies IP EQR, and also helps BB realize equity by leveraging the informational advantage of leading out with a well-balanced range that cannot be easily attacked by IP. This takes advantage of IP's lack of strong hands that would be happy to raise for value. This also limits the number of hands that can be raised as a bluff, resulting in IP having an overall low raising frequency of 20% on 654r, whereas IP has a raising frequency on A76r of 53% (GTO frequencies vs a donk bet-size of 1/4-pot).

Donk betting on A76r doesn't make sense because it does not help the BB deny IP EQR. In this case, the opposite actually occurs, because IP's range is so strong on this board that a donk bet can get raised with such a high frequency that the effect would be reversed. It would be the BB who is forced to continue putting more money into the pot with hands that would rather see a cheap turn card or fold, reducing their equity and resulting in a lower EQR and EV loss for OOP (*Table 101*).

Strategy	DK Bet%	Check %	EV	EQR	BB EV After Check	BB EV After Donk
GTO	0.0%	100.0%	25.0	63%	25.0	n/a
Donk Strong hands	10%	90%	12.8	32%	5.6	80.5
Donk Weak Hands	44%	56%	11.7	29%	40.6	-25.0
Donk Everything	100%	0%	12.8	32%	n/a	12.8

Table 101: A76r BB vs BN 30bb Stats for Different BB Strategies

A76r is so good for IP that they get to c-bet 100% of their range and not worry about being x/r too often. For this reason, the BB doesn't need to lead out with their strongest hands to get value as IP will keep putting money into the pot with their entire range when checked to. If the BB starts leading strong hands on A76r, it would only help IP as they could then choose to fold weak hands that would have continued putting money into the pot in the form of a c-bet and only continue when it is profitable to do so.

If we force the BB to donk every time they have top pair or better (10%), their total EV reduces from 25 to 13, as this strategy is highly exploitable. In the GTO solution, the checking range is well protected because the BB is never leading out but, in the locked strategy, the BB is donking their strongest hands, leaving their checking range vulnerable. This makes their EV after checking decline to 5.6. In this case, the BB's EV when betting is extremely high because the betting range is strong but betting only happens 10% of the time, while checking happens 90%.

If the BB starts to include many bluffs in the leading range, then IP would start calling wider and frequently raising the donk bets. If the BB tries a strategy of leading only with weak hands, the result is even worse as now IP will be able to raise 100% of the time, making the BB not only lose the entire pot when betting, but also their 1/4-pot size bet. For this reason, it works better for OOP to not split their range and simply check 100% on A76r.

If we subdivide all flops by donk betting frequency, we can get a better idea of how the ranges interact with the flops *(Table 102)*.

Donk Frequency Group	Average Donk %	OOP EQ	OOP EV	OOP EQR
50%+	60%	50%	52%	103%
25%-50%	34%	48%	47%	97%
10%-25%	16%	45%	43%	94%
0%-10%	1%	39%	30%	76%

Table 102: BB Stats by Donk Bet Frequency

Unsurprisingly, the highest equity and EV flops for the BB are also the highest frequency donk bet boards. However, it is important to understand that the high donk betting frequencies are an effect and not a cause. As we will see in this section, the main cause of the BB having higher equity and EV on some flops is the way the ranges are distributed which in turn results in higher donk betting frequencies.

High Donk Bet Frequency Flops (50%+)

There are about 34 distinct flops that result in an average donk bet over 50% of the time against both the BN and UTG. They are in ranks 7-x-x and 6-x-x with one to three possible flopped straights. The higher the number of flopped straights, the smaller the donk bet-size and the higher the donk bet frequency used. Rainbow flops are donked at a higher frequency than two-tone flops and, in general, monotone flops get donked a lot less frequently.

Flop	Donk 67% Pot	Donk 25% Pot	Check %	EQ	EV	EQR
632						
Rainbow	48%	3%	49%	48%	49%	102%
642						
Rainbow	49%	8%	43%	49%	52%	105%
643						
Rainbow	43%	23%	35%	51%	54%	107%
TwoTone	31%	26%	43%	50%	52%	103%
652						
Rainbow	50%	13%	37%	50%	52%	104%
TwoTone	35%	20%	46%	49%	50%	100%
653						
Rainbow	33%	28%	39%	51%	52%	102%
TwoTone	33%	26%	42%	51%	52%	101%
654						
Rainbow	12%	55%	33%	51%	54%	107%
TwoTone	11%	48%	40%	51%	52%	102%
753						
Rainbow	41%	13%	47%	49%	50%	102%
754						
Rainbow	17%	40%	43%	49%	52%	105%
TwoTone	30%	21%	50%	50%	49%	99%
763						
Rainbow	49%	16%	36%	49%	50%	102%
TwoTone	35%	19%	46%	49%	49%	98%
764						
Rainbow	18%	46%	36%	50%	54%	107%
TwoTone	32%	35%	33%	51%	54%	105%
765						
Rainbow	10%	60%	29%	50%	53%	106%
TwoTone	29%	31%	41%	51%	51%	100%

Table 103: High Donk Bet Frequency Flops

On the high donk frequency flops, the BB has an average of 50% equity and is able to over-realize that equity (103% EQR), capturing an average of 52% of the pot *(Table 103)*. The main reason why the BB over-realizes equity is the way the equity is distributed *(Diagram 26)*.

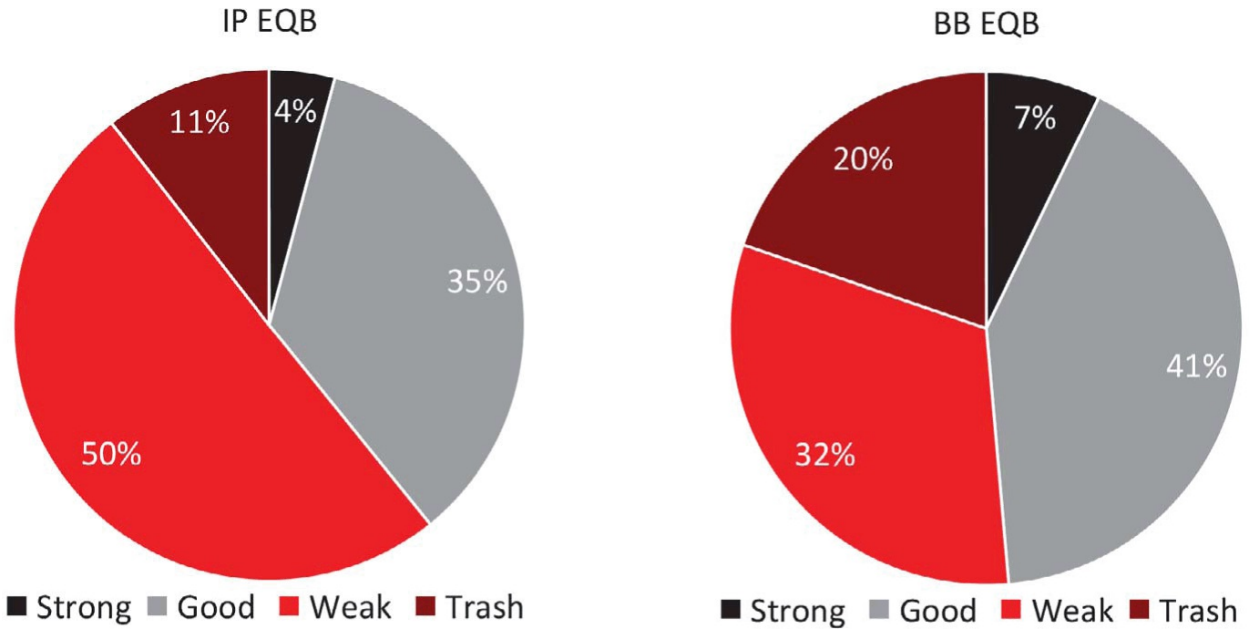


Diagram 26: EQB on High Donk Bet Frequency Flops

Here, the BB's range is more polarized than IP's range. The BB has the advantage in both strong and good hands, while 50% of IP's range are weak hands that will have a more difficult time realizing equity and will therefore benefit from playing passively. This range construction resembles the Clairvoyance Toy game, with the IP having the more depolarized range, which makes the BB want to take the betting lead.

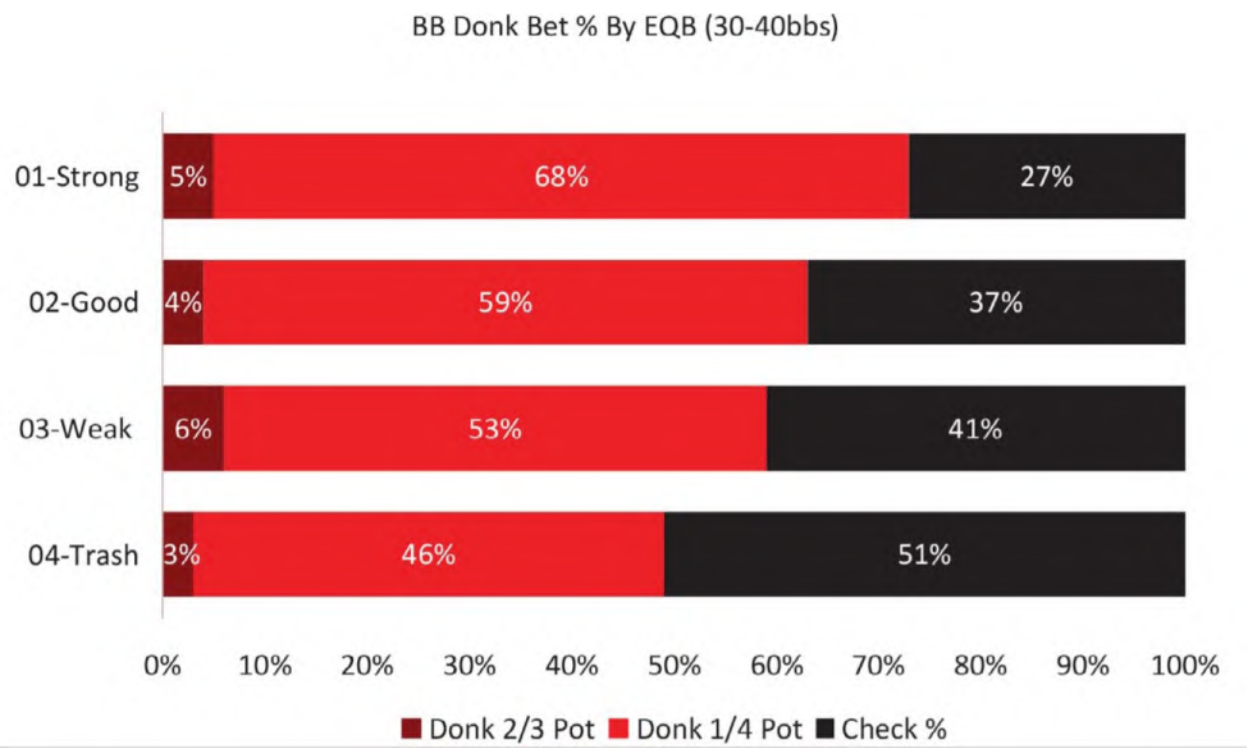


Diagram 27

With stack depths between 30-40bb, the BB wants to bet strong hands 73% of the time, good hands 64%, weak hands 59%, and trash hands are bet 49%. The most used donk bet-size is 1/4-pot, with 2/3-pot size bets used on average 5% *(Diagram 27)*. If we allow bigger bet-sizes in the simulations, the BB will even choose to overbet the pot with a small frequency, but the overall range composition on this type of high donk bet board seems to favor the small donk bet *(Diagram 28)*.

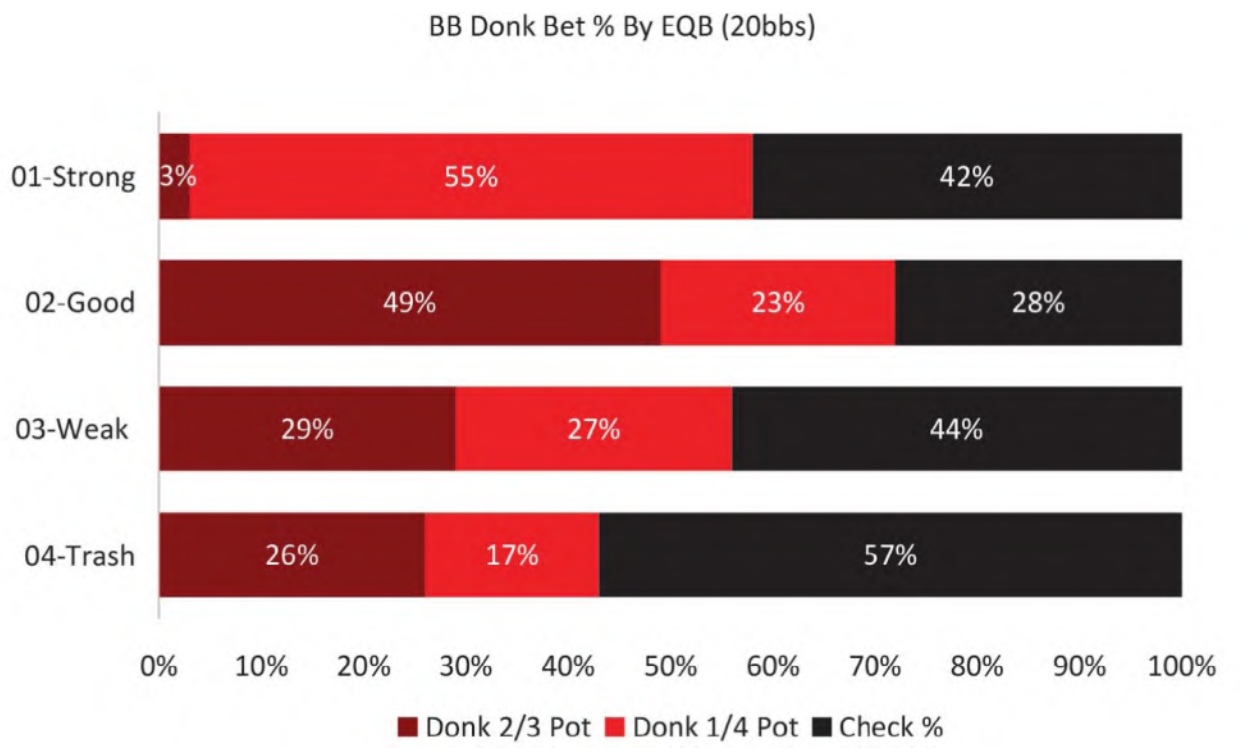


Diagram 28

With a 20bb effective stack, the 2/3-pot size donk bet is preferred. It seems that at 20bb, the BB's SPR is small enough that the BB is happy to stack off with a lot of good equity hands on the flop, so the bigger bet-size protects the BB's equity by getting more folds and helps the BB realize equity by getting all the money in on the flop when their equity is high. The BB's strongest hands seem to prefer the smaller bet-size because they aren't as vulnerable, so they don't mind getting called more frequently.

When stacks are deeper, there aren't many hands that are happy to get all-in on the flop so, instead, a smaller donk bet-size allows the BB to call a re-raise and see the turn without having to get all the money in on the flop.

Strong and good hands are also an important part of the checking ranges. The more checking happens, the more important it becomes to have strong and good hands in the checking range so the range remains balanced and protected.

Donk betting also happens on average more often vs UTG (67% of the time) than vs the BN (53% of the time). This is because the high donk betting boards are missed a lot more often by UTG ranges.

Donk Betting Range Example

BB vs UTG on 654r (30bb effective stacks)

Strong hands are bet 77% of the time

- **Straights** are the strongest hands the BB can have on this flop. The lowest straight 32 is the most vulnerable and it unblocks IP's continuing range, so it gets bet 91%, while the other straights 87 get bet 80% and 73 only gets bet 50%.
- **Sets**. Top set gets bet at a very high frequency (94%). The smaller sets are bet very infrequently (16-31%), because they don't block top pair.
- **Two Pairs** are bet at a very high frequency. 54 is bet with the highest frequency (96%), followed by 64 (94%) and 65 bets the lowest frequency (73%) because it blocks more of IP's continuing range and is also the least vulnerable.

Good hands are bet 70% of the time

- **Overpairs**. The strongest overpairs TT and 99 are bet 100% of the time, mid pairs 88 and 77 are bet 38% of the time.
- **Top Pairs** are bet 78% of the time. The ones with the highest kickers and the ones that have an OESD betting the highest frequency. The middle kickers are checked more frequently.
- **Second Pairs** are bet 71% of the time. The ones with the highest kickers and the ones that have an OESD betting the highest frequency. The middle kickers are checked more frequently.
- **Third Pairs** are bet 65% of the time. The ones with the highest kickers and the ones that have an OESD betting the highest frequency. The middle kickers are checked more frequently.
- **Under Pairs** 22-33 are bet 78%. 22 is bet more often than 33.

Weak hands are bet 61% of the time

♦ **OESD** are bet 67% of the time. 7x hands are bet more often than 3x.

♦ **Ace High** is bet 67% of the time in a reverse linear fashion. The weakest A-high being bet more often than the strongest ones. For example, A9s is bet 99% of the time and AQs is only bet 40%.

♦ **King High** is bet 54% of the time in a reverse linear fashion.

♦ **Gutshots** are bet 70% of the time. The ones that have two overcards being bet more often than ones with a single overcard.

Trash hands are bet 62% of the time

♦ **Air**, no pair, no draw, two completely disconnected overcards and gutshots with a 2 and no pair and combos with back door flush draw are bet more often than combos with no BDFD.

Mid Donk Bet Frequency Flops (25%-50%)

There are about 100 Flops that get donk bet 25-50% of the time. The main examples of flops that can generally be donk bet 25-50% of the time are: unpaired subfamilies 8MM, 8ML, 8LL, 7ML, 7LL, 6LL, and 5LL with one to three possible flopped straights. The only monotone flop is 764, and the paired flops are 766, 755, 655 *(Diagram 29)*.

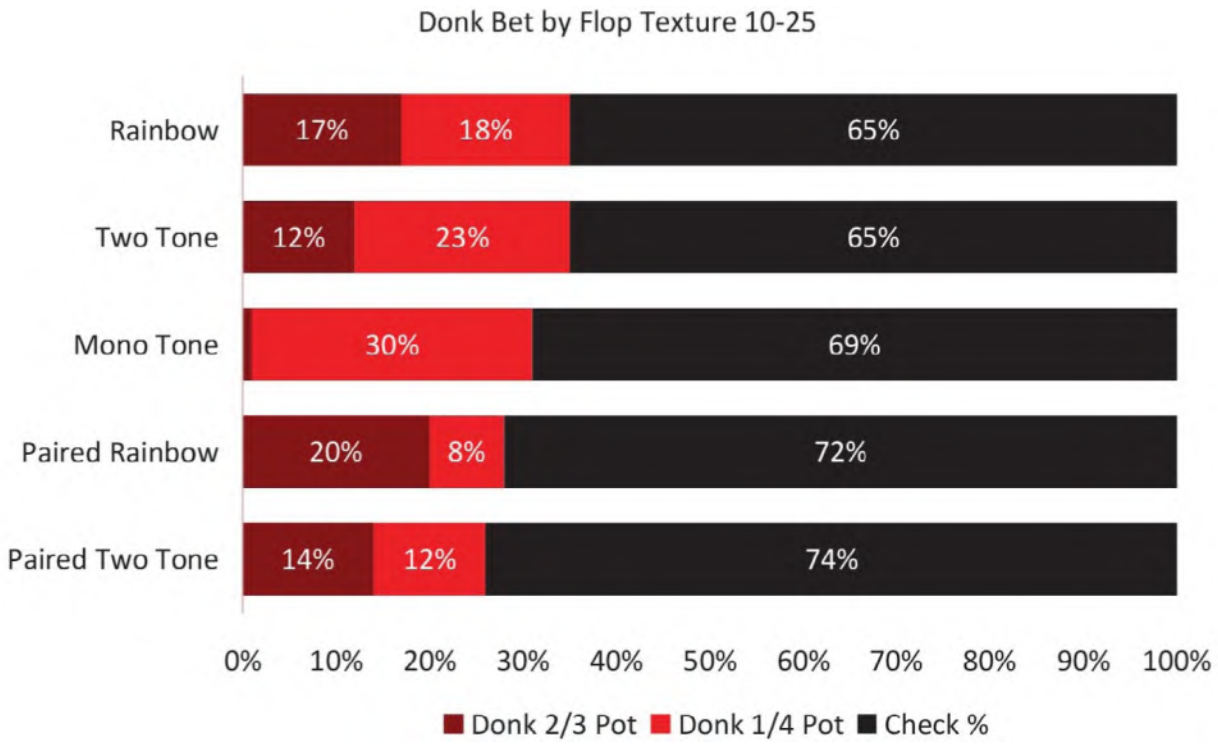


Diagram 29

Donk betting happens with the same frequency against UTG and the BN, roughly 35% of the time and checking happens 65% of the time, as the equity distribution doesn't change too much in either case.

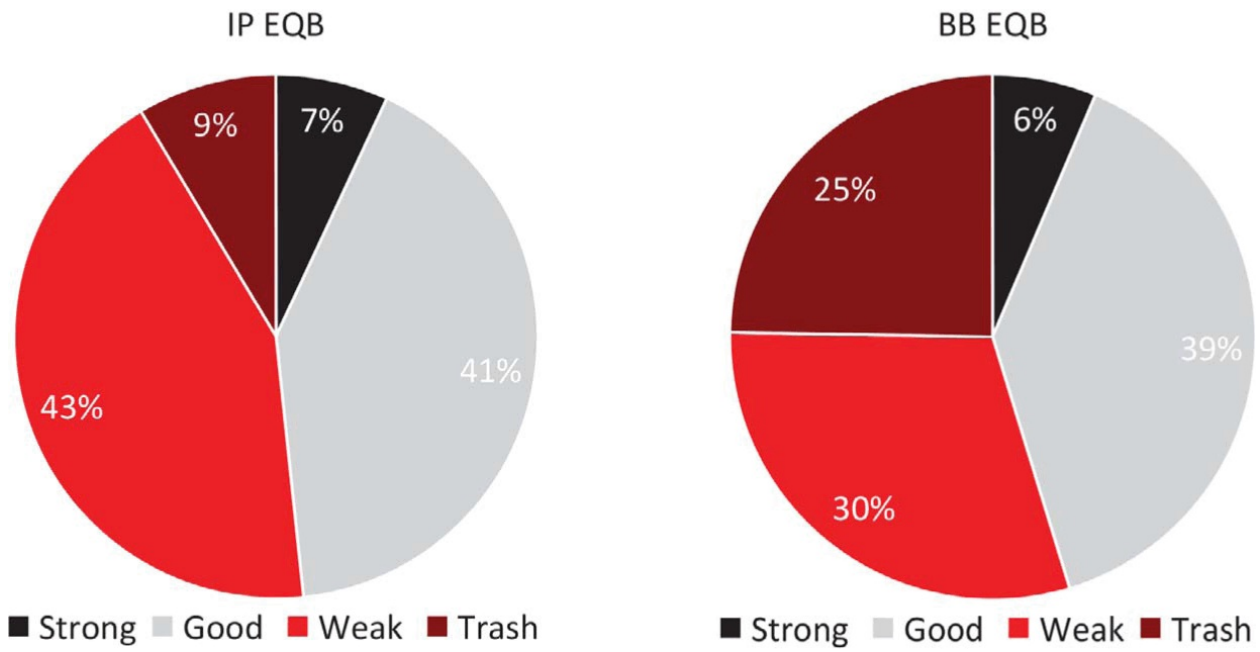


Diagram 30

On the mid donk bet flops, equities run very close. IP has a slight equity advantage, 52% compared to the BB's 48%. However, the BB's range is more polarized with the bulk of the range being strong, good and trash hands, while IP still has a lot of weak hands that benefit from playing passively and seeing free cards in order to realize equity *(Diagram 30)*.

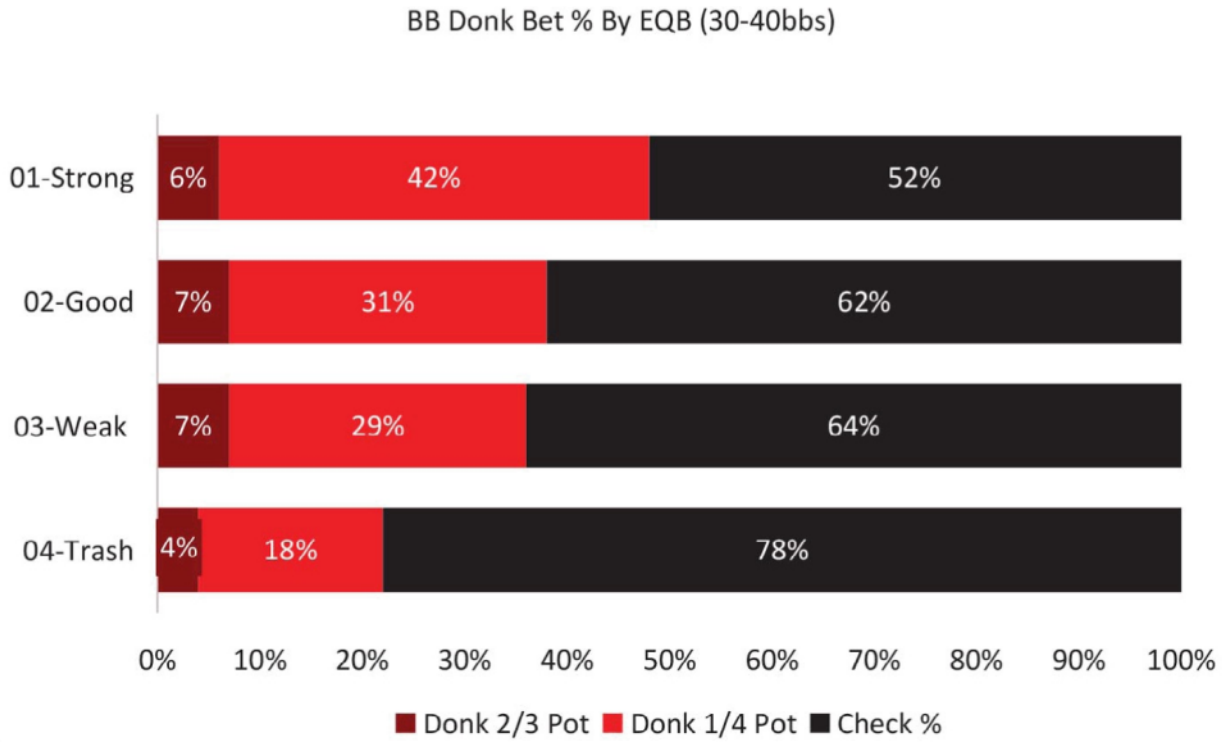


Diagram 31

With 30-40bb, strong hands prefer using the bigger bet-size on paired boards and a smaller size on unpaired boards. Hands are bet linearly according to their equity with the highest equity hands being bet more often than low equity hands. The structure of the betting ranges is similar to what we saw previously in the High Donk Bet frequency flops, betting the same type of hands, but doing so with a lower frequency, checking everything more often so the checking range is more protected *(Diagram 31)*.

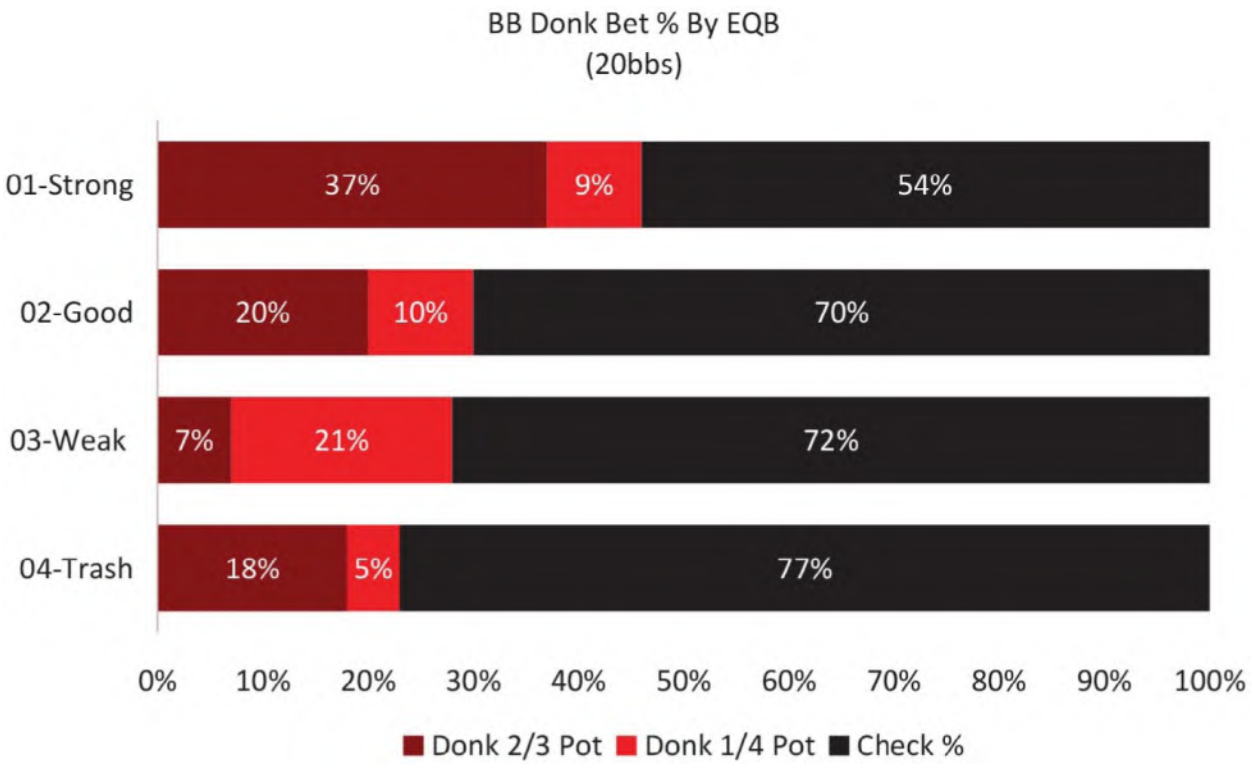


Diagram 32

With 20bbs, the donking strategy is extremely polarized, betting mostly strong, good and trash hands. For this reason, a bigger bet-size is preferred, with the smaller size being used in the opposite way, mostly with weak hands, but also with some frequency of strong, good and trash hands in order to make the strategy well balanced *(Diagram 32)*.

Low Donk Bet Frequency Flops (10%-25%)

Approximately 181 distinct flops get donk bet with 10% to 25% frequency. In this situation the 67%-pot size bet is preferred (9%) over the 25%-pot size bet (7%). The BB donks slightly more frequently against the BN (16%) than against UTG (14%).

The unpaired donked flops subfamilies are: ALL, 9MM, 8MM, 8ML, 8LL, 7ML, 7LL, 6LL, 5LL, and 4LL.

The paired families are: 99A, 88A, 77H, 77M, 77L, 66A, 66H, 66M, 66L, 55A, 55H, 55M, 55L, 44H, 44M, 44L, 33M *(Diagram 33)*.

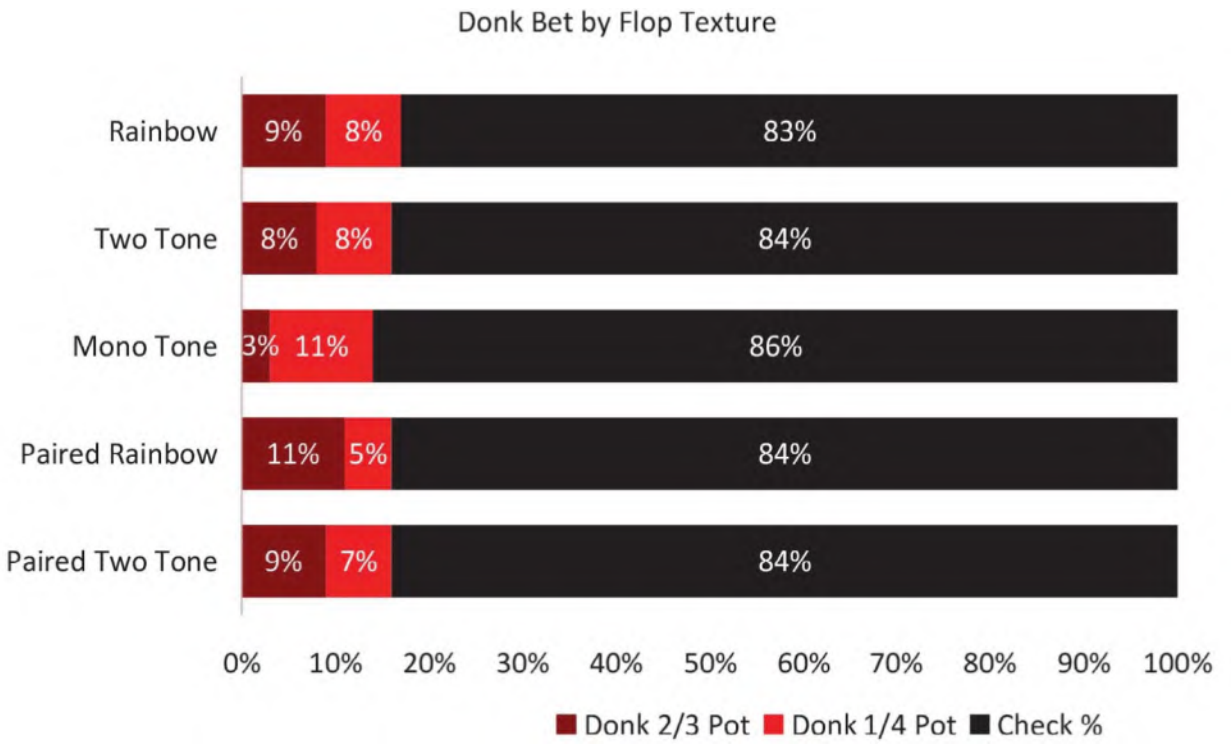


Diagram 33

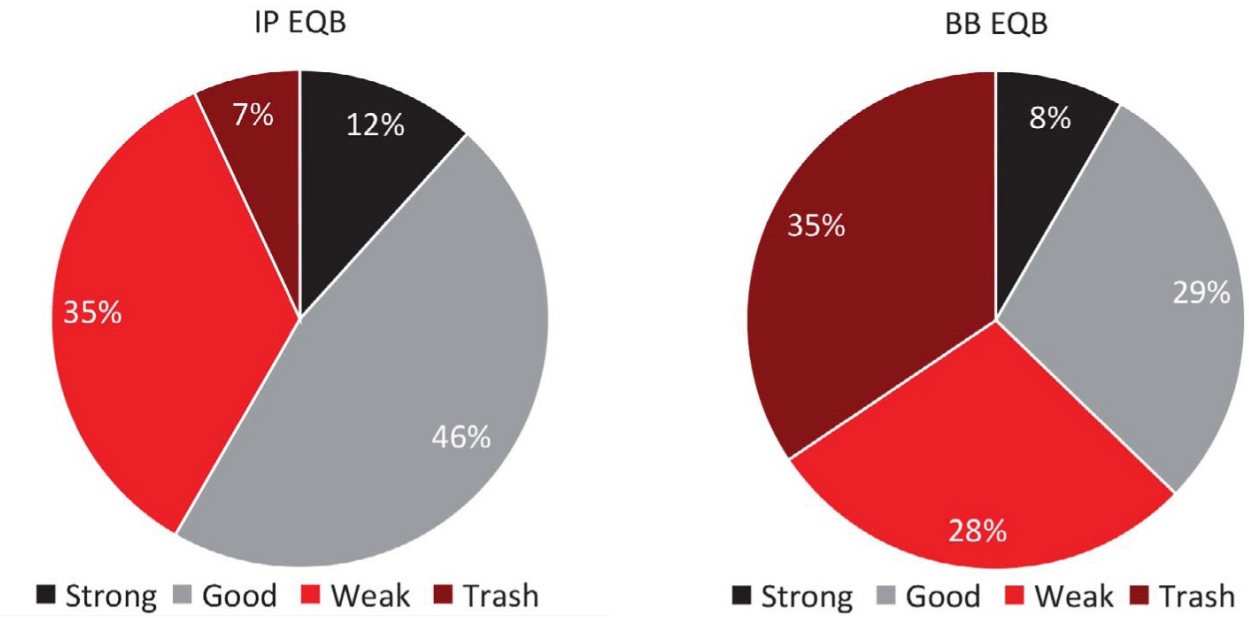


Diagram 34

In low donk bet frequency flops, IP's range dominance is clear *(Diagram 34)*. OOP's equity drops to 45% and under-realizes by 6%, capturing only 43% of the pot. The number of OOP trash hands finally outweighs the number of weak hands. OOP's strong and good hand

percentage is significantly lower than IP. For this reason, checking starts to become the dominant strategy.

On low frequency donk bet flops, the donk betting ranges are a little more polarized and, for this reason, a larger bet-size is preferred. Donk betting does not seem to be too affected by stack depth and so the frequencies are similar with 20bb, 30bb and 40bb effective stacks *(Diagrams 35-36)*.

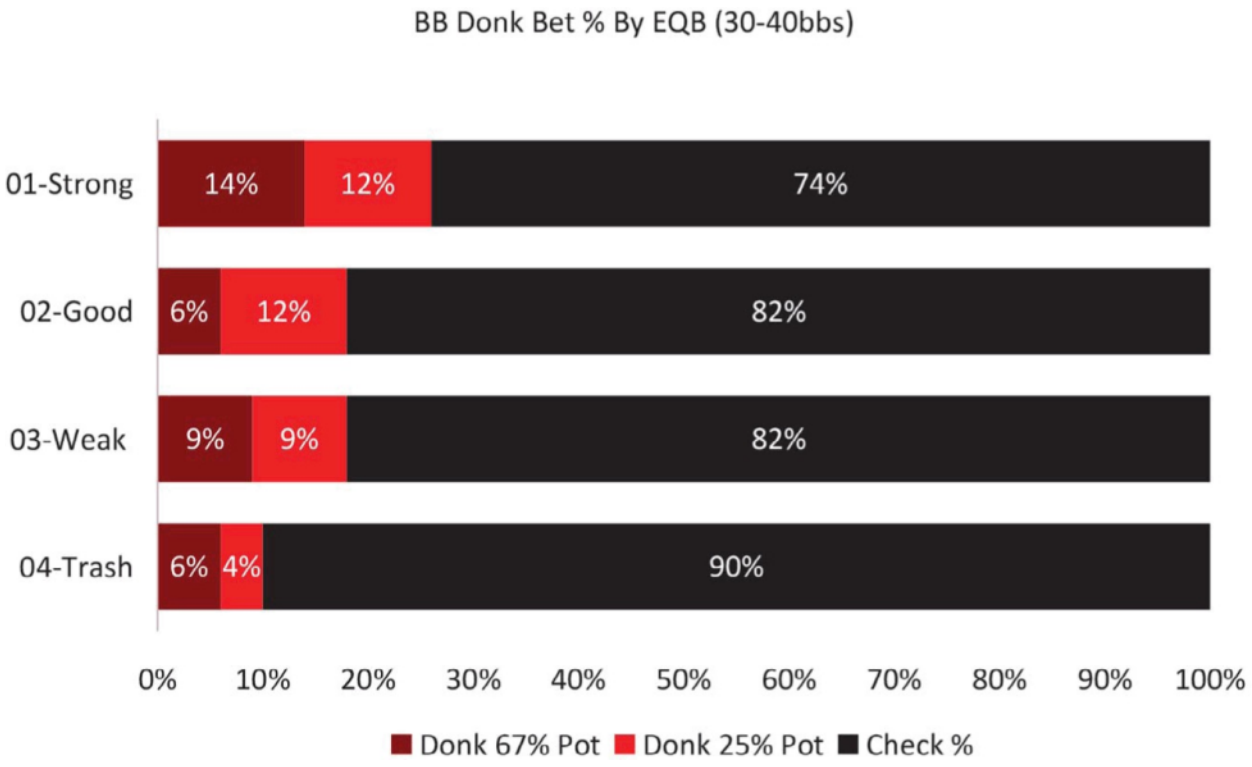


Diagram 35

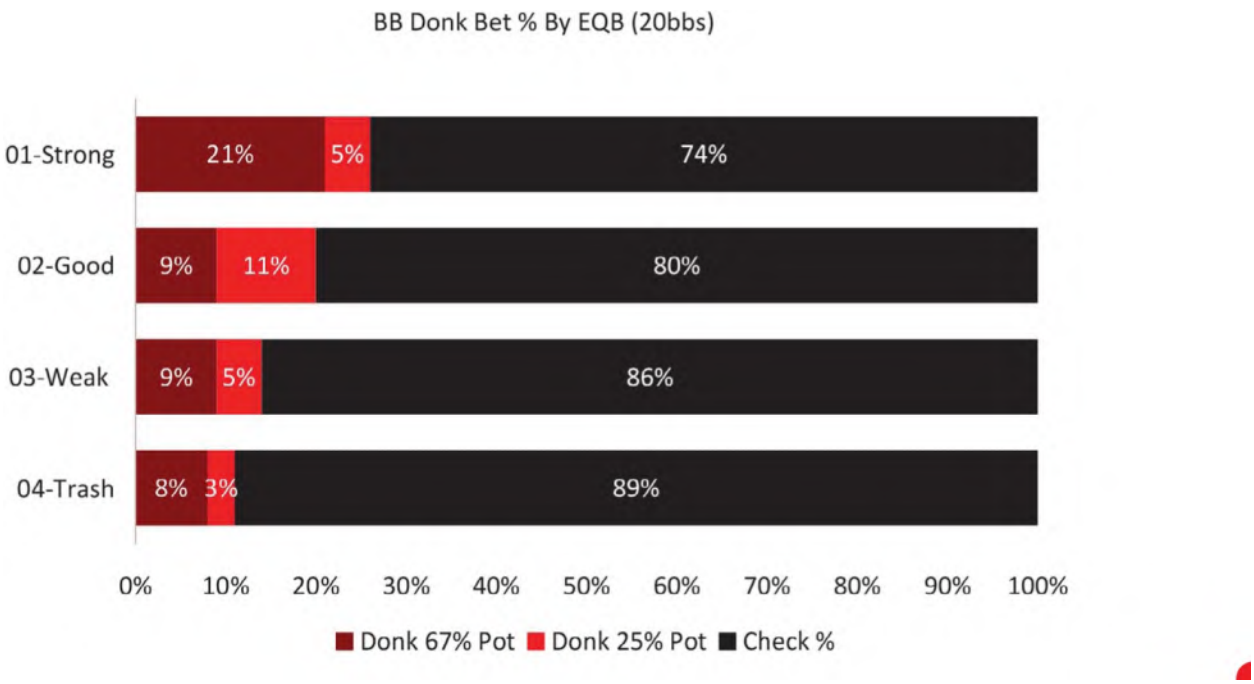


Diagram 36

No Donk Bet Flops (0%-10%)

The vast majority of flops belong to this category. Pretty much all flops that were not included in any of the other groups. In general, this means trips, monotone, high card paired, disconnected two-tone, HXX and AXX flops are bad donk betting flops.

In general, this group of flops are bad for the BB, providing an average of 39% equity and low EQR of 76%, for an average EV of 30% of the pot. On these boards, IP's range is so strong that OOP is forced to check with a high frequency, for an average donk bet frequency of about 1%. OOP's range is so weak that it doesn't have enough strong hands compared to IP to be able to split this range so, for the most part, removing the option to donk bet on these kinds of flops does not reduce BB's EV too significantly. Playing a 100% checking frequency is recommended.

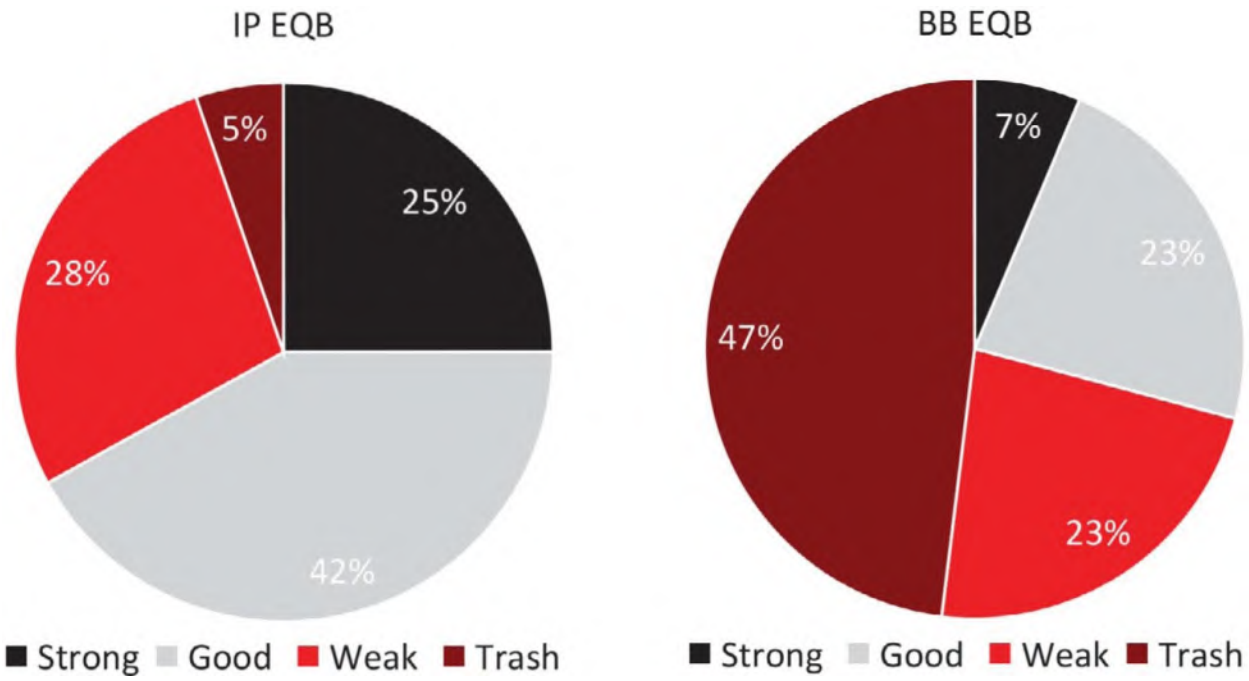


Diagram 37

Flop families that have similar structures and textures tend to be played in a similar fashion. So if you want to dig deeper into donk betting range composition, I recommend running sample flops from each donk bet frequency group in a GTO solver to familiarize yourself with the different spots, how to react to flop raises and how to follow through on future streets.

The Value of Donk Betting

The general consensus states that donk betting is bad and should not be done. However, as we have just seen, donk betting is widely used by the solver on some flop textures. Given that donk bets are rarely used, how big of a mistake is it to opt for a simpler strategy that always checks to the pre-flop aggressor when OOP in a SRP?

In *Table 104* we can see the key flop metrics of BB vs BN with a 30bb effective stack on the 654r flop. The GTO strategy is compared to a simulation where the BB's donk betting option is removed to make the BB check 100% of their range.

Strategy	Donk 1/4 Pot	OOP EV	bb/100	OOP EQR
GTO	57.4%	51.9%	290.81	100.6%
100% Check	0.0%	50.8%	284.31	98.35%
100% Donk	100.0%	50.8%	284.54	98.4%

Table 104: 654r BB vs BN 30bbs Stats

654r is one of the highest donk bet flops. When the BB loses the ability to lead out on this board, they lose 1.1% of the pot or 6.5bb/100 and the EQR decreases by 2.25%. In a 5.6bb pot, playing a 100% donk bet strategy cost the BB 6.27bb/100 when playing against a minimally exploitative opponent.

The value of donk betting will change depending on the SPR and what the value of the option for the OOP player to bet is. For example, on the A76r flop, OOP should donk bet about 0.4% of the time and, if we remove the BB's option to donk bet, their overall EV remains the same.

Donk betting only happens at a high frequency on a small number of flops that are also low frequency flops, so the impact of the EV loss of choosing a simpler strategy that always checks when OOP will not be significant in the grand scheme of things. Additionally, implementing donk betting strategies correctly can be difficult in-game. That said, if you play in really tough games where every possible edge counts, taking the time to study and incorporate donk bets can become a valuable tool, particularly if your opponents are not used to dealing with flop donk bets, which can result in them making more mistakes that you could potentially capitalize on.

You can of course also choose to donk bet exploitatively against weaker players. For example, if you know that the Villain will c-bet at a high frequency but would never raise a donk bet without a strong hand, you can put in a small bet with some hands that will work as a blocking bet, allowing you to see the next card cheaply with some weak hands while giving you information on your opponent's holding.

Another example is if you know the Villain is overly aggressive and will almost always raise a flop donk bet. Then, you can lead out with very strong hands to induce a raise from the Villain. This would of course leave you exposed to counter exploitation, so it requires excellent knowledge about your opponent's tendencies.

The Power of Position

In this section, we will use the high and low donk bet frequency flops 654r and A76r in BB vs BN situations with 30bb effective stacks. We will compare the GTO simulations against

modified hypothetical simulations that will help us better understand the effect of being IP and OOP post-flop.

GTO: Modified GTO Solution with new flop bet-sizings for both players: 1.25-pot, 2/3-pot, 1/4-pot.

Positions Flipped: Modified solution where the players' ranges are flipped, so now OOP has the BN range and the IP Player has the BB range.

Hero Range	Posi-tion	Simu-lation	Flop	Bet 125%	Bet 2/3	Bet 1/4	Check %	EQ	EV	EQR
BN	IP	GTO	A76r	3.2%	61.6%	33.3%	1.9%	59.9%	75.0%	124.4%
BN	OOP	Flipped	A76r	38.3%	16.9%	43.7%	1.2%	59.9%	68.3%	114.1%
BN	IP	GTO	654r	5.6%	20.0%	22.9%	51.6%	48.4%	48.1%	99.4%
BN	OOP	Flipped	654r	7.7%	0.4%	1.2%	90.8%	48.4%	38.4%	79.4%

Table 105: Result of Flipping BN and BB Ranges from BN Perspective

Hero is on the BN and opens a standard GTO 49% opening range and the action folds to the Villain in the BB who calls with a standard 64% GTO range. Now imagine the positions are flipped on the flop, but both players keep their original ranges. Now Hero is OOP with a 49% BN range, and the Villain is IP with a 64% BB calling range *(Table 105)*.

Let's start by analyzing what happens to Hero after flipping the positions.

On A76r, Hero's range is so strong compared to the Villain's that Hero still over-realizes equity, but not as much as with position. Hero's EV reduces from capturing 75% to only being able to capture 68.3% of the pot, costing Hero 6.7% of the pot. Hero's strategy also changes. It is still optimum to bet 100%, but now the 125% and 1/4-pot bet-sizes are used more than the 2/3-pot sizing.

When playing IP, Hero's strategy is almost always aimed to bet across three streets. For this reason, the 67% size is used more often as it allows an effective triple barrel. When we flip the positions, some elements of Hero's range only want to play a two street game. Therefore, after overbetting the flop and getting called, Hero will mostly go all-in or check on the turn. After checking and facing a bet, Hero will mostly x/r all-in or fold. This way, Hero reduces the positional disadvantage.

On 654r, Hero has a range disadvantage so, unlike on A76r, betting the entire range isn't

advisable because the risk of the check-raise (which would destroy Hero's equity) increases drastically. So, with position, Hero can only bet about 48% of the time after the BB checks. When Hero is OOP with the BN's range on this flop, the total betting frequency drops down to 9.23% and the most used bet-size is the 125% overbet. Again, Hero aims to play a two street game and go all-in on the turn with a reasonably high frequency.

Weak hands make up 51% of Hero's range. When in position these would be checked back most of the time to realize equity and would prefer to play a small pot, so as not to risk being x/r and blown off their equity. Unfortunately, when checking OOP, Hero is not guaranteed to see a turn card and will instead often face a bet and be forced to give up equity with many hands that would benefit from seeing a free turn card. For this reason, when OOP, Hero has to check many strong hands that can x/r the flop, forcing the Villain to bet less often, and thus allowing Hero's weak hands to realize equity. If Hero does not protect the checking range, Villain will bet at a higher frequency, costing Hero a lot of EV. For this reason, Hero's checking frequency is even higher when OOP with a range disadvantage. When OOP on 654r, Hero's EQR decreases from 100% to 79%, costing 9.7% of the pot!

Next, we will analyze the same situation from the Villain's point of view, with the BB now being in position, and compare it to the GTO simulations. In the flipped simulations we will assume OOP checks 100% of the time to IP, so the ranges are the exact same as when the BB was OOP *(Table 106)*.

Villain Range	Posi-tion	Simu-lation	Flop	Bet 125%	Bet 2/3	Bet 1/4	Check %	EQ	EV	EQR
BB	OOP	GTO	A76r	0.0%	0.0%	0.0%	100.0%	40.1%	25.0%	63.0%
BB	IP	Flipped	A76r	0.2%	0%	0%	100%	40.1%	37.8%	94.13%
BB	OOP	GTO	654r	6.2%	8.8%	42.4%	42.6%	51.6%	51.9%	100.6%
BB	IP	Flipped	654r	0.5%	3%	52.1%	44.4%	51.6%	61.9%	119.9%

Table 106: Result of Flipping BN and BB Ranges from BB Perspective

On A76r the Villain's range is so weak compared to Hero's range that, even when having position, it is best to check back 100% of the time as betting would result in being x/r at a very high frequency. The main difference is that, after checking back the flop, the Villain gets to realize a lot more equity than when OOP and gets forced to fold a lot of weak and trash hands that will improve to made hands or draws on the turn. This results in a huge EV increase from 25% when OOP to 37.8% when IP for a total gain of 12.8%!

On 654r pretty much all hands that wanted to bet when OOP still want to bet when the Villain

is IP. The main difference is that now the larger bet-sizes aren't as necessary and the Villain opts to use the 25% bet-size almost exclusively. In this case the BB increases their EV by capturing an extra 10% of the pot.

Symmetric Ranges: Modified solution where both players have the exact same range. We will examine one example with both players having the BB range and another with both players having the BN range *(Tables 107-108)*.

Position	Simulation	Flop	Bet 125%	Bet 2/3	Bet 1/4	Check %	EQ	EV	EQR
IP	Symmetric BN	654r	1.00%	32.60%	17.30%	49.10%	50.00%	55.30%	110.50%
IP	Symmetric BB	654r	1.60%	32.00%	15.90%	50.50%	50.00%	55.30%	110.50%
IP	Symmetric BN	A76r	0.40%	1.10%	49.90%	48.70%	50.00%	54.50%	109.00%
IP	Symmetric BB	A76r	0.50%	5.60%	51.20%	42.70%	50.00%	55.20%	110.40%
IP	Average		0.88%	17.83%	33.58%	47.75%	50.00%	55.08%	110.10%

Table 107: Symmetric Ranges from IP Perspective

Position	Simulation	Flop	Bet 125%	Bet 2/3	Bet 1/4	Check %	EQ	EV	EQR
OOP	Symmetric BN	654r	10.30%	3.70%	6.50%	79.60%	50.00%	44.70%	89.50%
OOP	Symmetric BB	654r	0.122	0.031	0.051	79.60%	50.00%	44.70%	89.50%
OOP	Symmetric BN	A76r	0.50%	1.70%	12.20%	85.70%	50.00%	45.50%	91.00%
OOP	Symmetric BB	A76r	0.006	0.101	0.065	82.90%	50.00%	44.80%	89.60%
OOP	Average		5.90%	4.65%	7.58%	81.95%	50.00%	44.93%	89.90%

Table 108: Symmetric Ranges from OOP Perspective

Despite having identical ranges, the IP player captures on average 5% more of the pot than 50% equity, for a total EQR of 110%. Meanwhile OOP only realizes 90% of their equity, capturing on average only 45% of the pot.

Different experiments that use different sample flops, or even a large subset of flops, give results that are consistent with the value of position being between 5-10% of the pot.

The more streets left to play, the bigger IP's information advantage becomes as IP gets to act last on each street. As mentioned previously, every action taken at the table conveys information,

so every time OOP takes an action, this reveals some information about their range to IP, who can use this information to his advantage before having to make a decision. This continues to the river, where IP will have the most complete information possible regarding OOP's range. Furthermore, when studying complex strategies in Chapter 4, we established that there is a direct correlation between stack depth or SPR and Hero's ability to realize equity. Deeper stacks benefit the IP Player and hurt the OOP player. For this reason, OOP tends to use larger bet-sizings than IP, either to get more folds and end the hand immediately or, if called, to decrease the positional disadvantage by reducing the SPR.

Another measure OOP takes to decrease positional disadvantage is to avoid splitting their range on flops where they have a large range disadvantage and thus not give away any information to IP by checking 100% of the time, as seen in the donk betting section of this chapter.

Being IP with a weak range is not as bad as being OOP with a weak range. In general, strong ranges will realize most of their equity and sometimes even over-realize it when OOP, while weak ranges heavily under-realize their equity when OOP. For this reason, over-folding the big blind to steals was a predominant strategy in both live and online poker for many years as players generally tried to avoid this unfavorable situation. This in turn created an opportunity for observant players to capitalize on this by loosening up their opening ranges and attacking the tight players' big blinds. Subsequently, players started to readjust their BB strategy and began calling very wide vs open raises, which resulted in the BB defending way too many marginal hands that made post-flop play too difficult for the BB, hurting their overall EQR.

Now, with modern solvers, both pre- and post-flop play have in general improved drastically, resulting in players defending in a close to optimal fashion from the BB. This is particularly true in high stakes online cash games where most regulars play a sound baseline pre-flop GTO strategy and are now forced to look for possible edges elsewhere. However, even at the highest level, players still make mistakes. The game is not completely solved and there is always room for improvement and exploitation.

> *The goal with this chapter is to improve the players' underlying understanding of the game so that they are capable of finding these edges by themselves and to turn them into winning strategies applicable to their own games.*

THE FLOP CONTINUATION-BET (C-BET)

Flop c-betting is one of the most important topics in poker. It is a complex subject that has been studied and discussed by poker players and theorists for decades. Contrary to most typical theory books, I decided to begin the flop discussion with the BB instead of leaping directly into c-betting. This is because I want readers to first develop a good conceptual understanding of betting in general, how the post-flop action is a function of the players' relative positions, range distributions and SPR. After studying OOP betting and the power of position, all that is left in order to understand the flop c-bet is to analyze the situation from the IP player's point of view.

Just as we did when studying the donk bet, for this section we will use the aggregated data from thousands of GTO solutions with stack depths 20bb, 30bb and 40bb with standard GTO MTT starting ranges. The ranges in your own games might be different to the ones used for these simulations, but I have found that, as long as the ranges used are "reasonable", the overall results for post-flop play won't be significantly affected. If the standard ranges in your own games differ too much from the equilibrium strategies, you can still benefit by understanding equilibrium and then applying the principles discussed in this chapter to understand how your standard ranges are different from GTO and how you can deviate from equilibrium to further attack the imbalances introduced in the new strategies. Getting your own solver and running some custom simulations can help you better understand this effect and find good exploitative lines against population tendencies.

In the previous section we found that, from a GTO point of view, there isn't too much incentive for OOP to bet out on the flop, but what about IP? What is their equilibrium strategy? Are they incentivized to bet or check? Can they play a pure strategy that always checks back the flop without a significant EV loss in the way the BB can?

Strategy	EV
GTO 4 Bet sizes	70.9784
100% Check	66.8104
EV Difference	4.168
EV loss in bb	0.258416
EV loss bb/100	25.8416

Table 109: Result of IP Playing 100% Check Back

If IP plays a strategy that always checks back the flop, they will have an EV loss of 26bb/100, so c-betting the flop is of *massive importance* to IP. In this section, we will study the principles behind the flop c-bet and use that knowledge to effectively develop sound c-betting strategies.

Overall Flop Metrics

This analysis starts on IP's decision point after the BB checks. For these calculations, we used simulations where the BB had the option to donk bet. However, donk betting happens very infrequently and, in general, checking GTO ranges will remain well balanced even when donk betting is widely used. Therefore, we can expect IP's overall strategy to not be affected and be applicable to players who have a GTO donking range and players who check 100% of the time.

Players who have a non-GTO donking range are in general quite exploitable as their donking range tends to be always strong or always weak, so all you need to do against them is figure out their strategy. If they always donk strong, you can start to overfold the bottom of your range when they bet and bet at a high frequency when they check. If they donk weak, you can bluff raise them on the flop, trap them with your really strong hands that don't need much protection, and check back the flop a little more than usual to avoid being x/r by a checking range that is heavily skewed towards strong hands.

IP	EQ	EV	EQR
UTG	63%	73%	115%
BN	59%	67%	115%
Average	60%	69%	115%

Table 110: IP vs BB Overall Metrics

Both the BN and UTG over-realize their equity by 15%, but since UTG's range has higher equity, they are able to capture a bigger portion of the pot than the BN (*Table 110*).

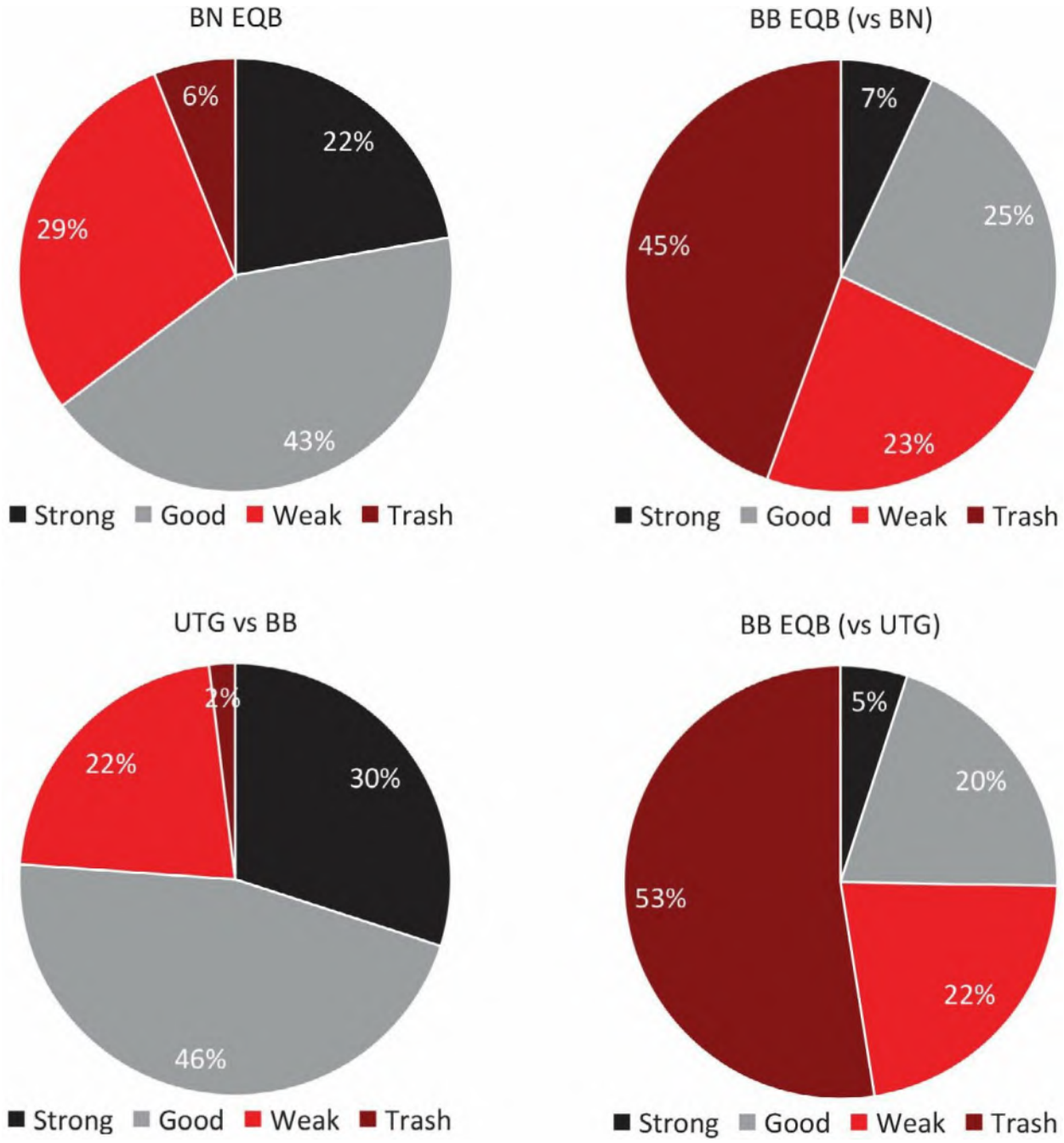


Diagram 38: BB vs IP Equity Buckets

Clearly IP has the overall range advantage. As expected, UTG's ~15% range is much stronger than the BN's ~44% range *(Diagram 38)*. This aligns well with UTG's higher c-bet frequency.

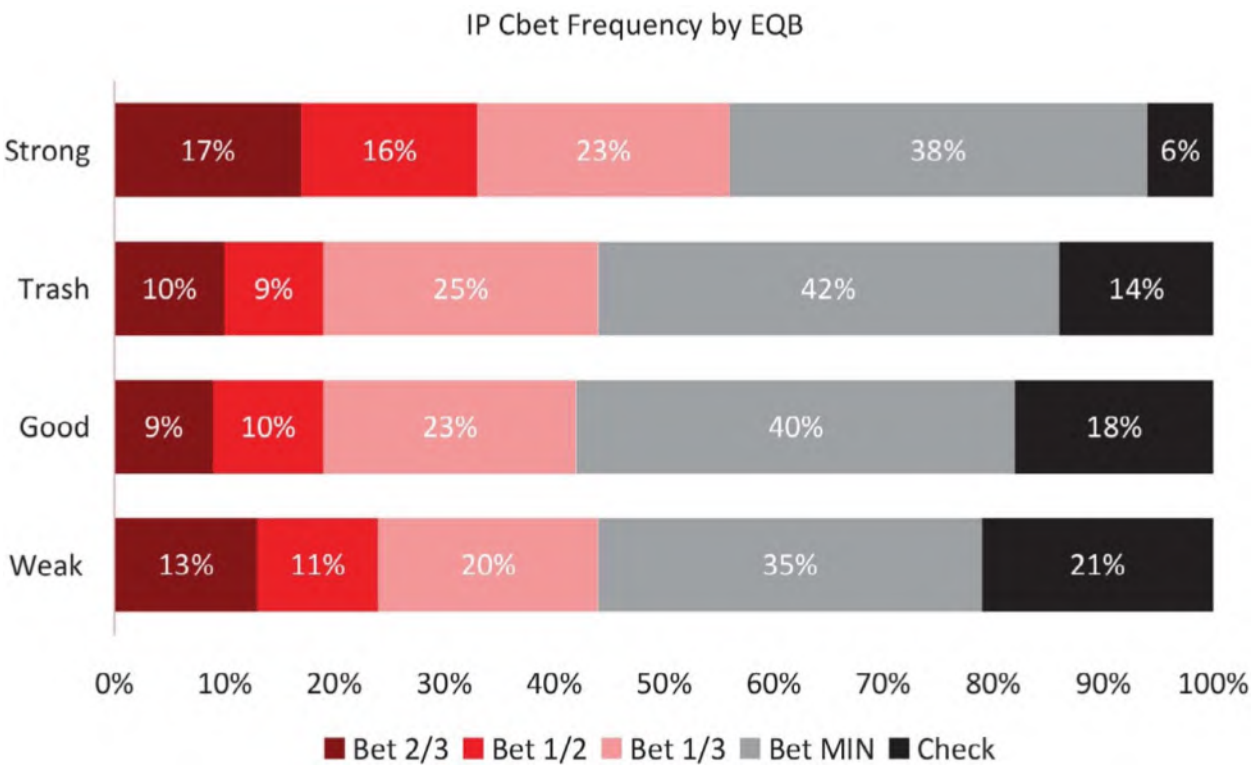


Diagram 39

Strong hands

Strong hands are incentivized to bet and increase the size of the pot but, as we know, betting only your high-equity hands and checking your low-equity hands would be a highly exploitable strategy. For this reason, IP also has to bet some weaker hands on the flop so that the c-betting range remains balanced.

Sometimes checking back strong hands works well in situations when they don't need as much protection. When they block the Villain's continuing range, or when they are so nutted that it doesn't matter if you give a free card so the Villain can catch a small piece or start bluffing, checking behind with some of your strong hands makes sense. This is referred to as *trapping*. An added benefit is that checking strong hands also helps protect your checking range.

Good hands

Good hands also benefit by betting and gaining value from worse hands as well as for protection to get some folds from hands that have equity. However, sometimes it makes sense to check back your good hands when the BB's range is very polarized to hands that are either stronger than yours or have very little equity. By checking behind, you give the Villain a chance to pick up

some equity with trash hands or start bluffing with them, while keeping the pot size under control when you are beat. This action is often referred to as *pot controlling.*

Weak hands

Weak hands benefit from checking back when the Villain's range is strong and you risk getting x/r and pushed off your hand. However, they do well as *semi-bluffs* when your opponent's range is generally weak and cannot x/r you at a high frequency.

Trash hands

Trash hands will not improve too often when checked back, so they are in general c-bet more often than weak hands. They mostly benefit from having fold equity. If called, they will still have some equity in the pot, but their equity is sufficiently low that you don't mind having to bet/fold them vs a x/r. Betting your trash is often referred to as a *pure bluff.*

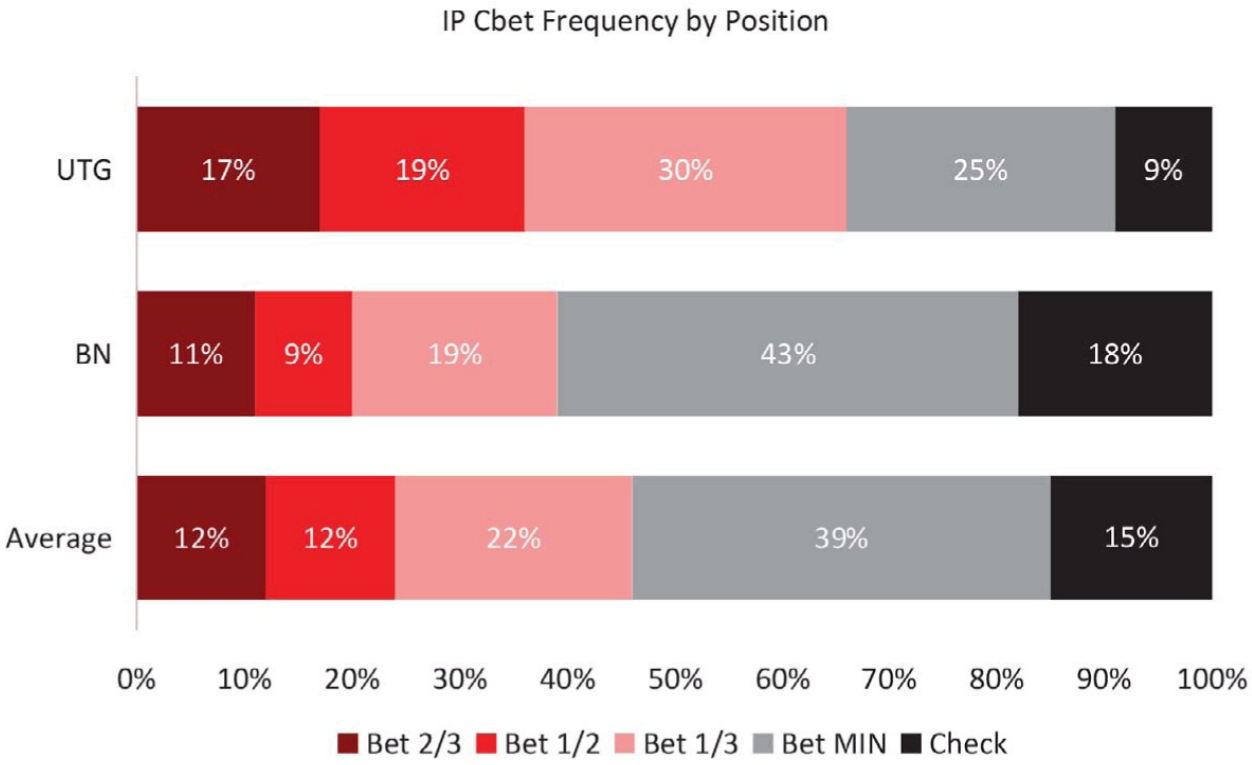


Diagram 40

UTG's c-bet frequency and bet-sizes are bigger than the BN because the UTG range is stronger than that of the BN. In general, the more strong hands your range has compared to your opponent's, the more frequently you can bet. This is because the more strong hands your betting

range has, the more you can bet other hands in your range because your range is protected. The fact that UTG's range is in general stronger than the BN's also allows the use the bigger bet-sizes more frequently *(Diagram 41)*.

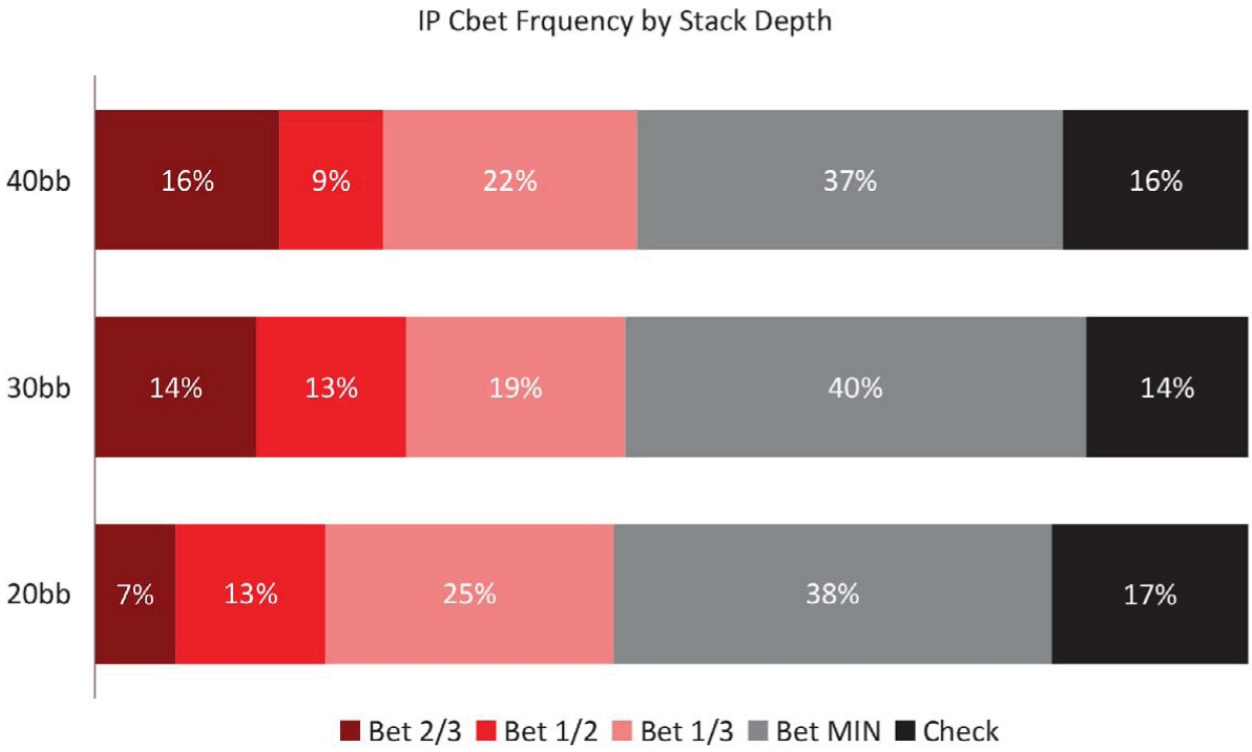


Diagram 41

The bigger sizes are generally used less often when stacks are shallower, and the use of bigger bets (and even overbets) becomes more relevant when stacks are deeper. This makes sense because, in general, when stacks are shallow, big bets aren't needed to get all the money in across two or three streets. There is no need to overcommit large portions of your stack when the SPR is low. The only exception is the all-in bet, which gets used more often when stacks get shallow, because the risk/reward ratio is much better when all your chips are going in and you are guaranteed to realize your equity *(Diagram 41)*.

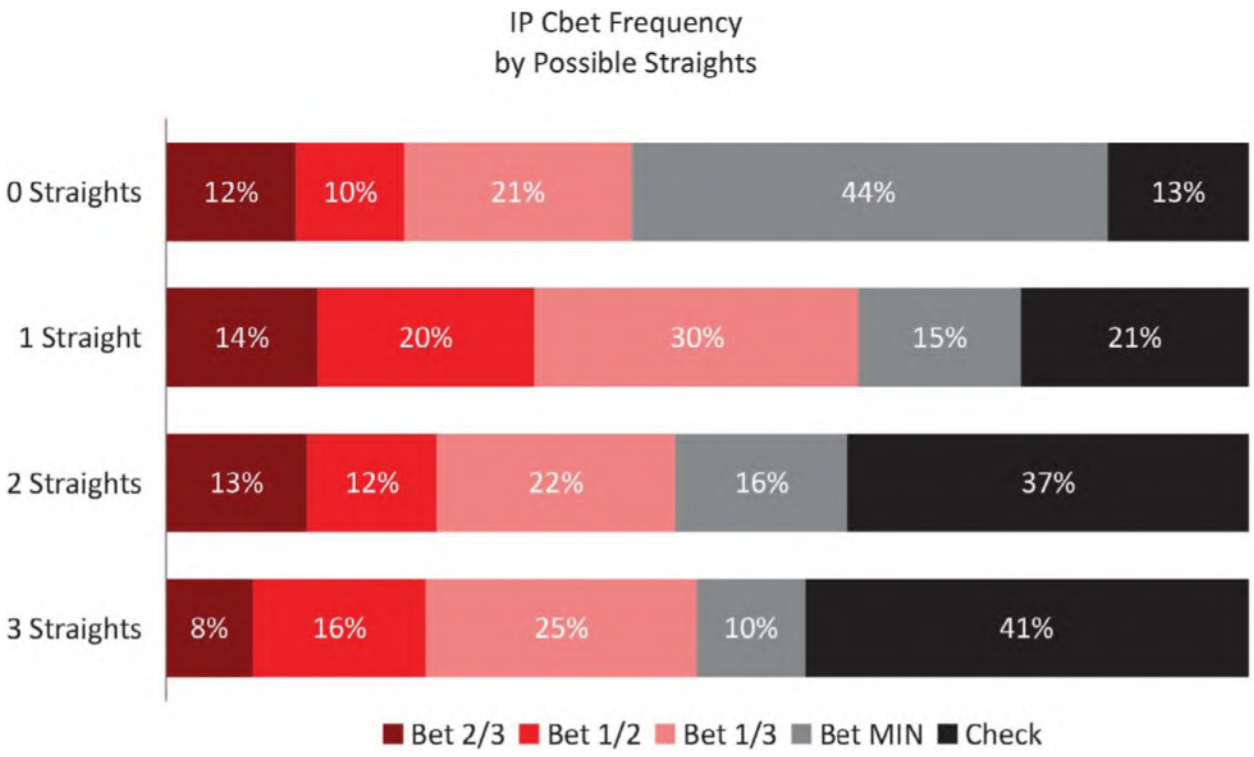


Diagram 42

Since the BB has more offsuit connectors than IP, flops with more possible flopped straights will, as expected, favor the BB. So, the c-bet frequency decreases as there are more straights possible on the flop. Flops with zero flopped straights are the highest c-bet ones.

Within the flops with zero possible straights, we can create a subcategory for the number of possible open-ended straight draws *(Diagram 42)*.

Not surprisingly, the flops with three OESDs are the ones with the lowest c-bet frequency and with the larger bet-sizes, as the BB will have more possible straight draws and IP's strong hands need more protection *(Diagram 43)*.

The only 2xx flop is 222 and it is c-bet 100% of the time. Axx flops are the second most c-bet flops, with a 96% c-bet frequency. 3xx flops are only 333, 322 or 332 and are c-bet 93% of the time. Kxx flops are c-bet 88%, Qxx and Txx are c-bet 85% and, as expected, middle and low flops are c-bet at the lowest frequencies, with 6xx being the lowest at only 62% *(Diagram 44)*.

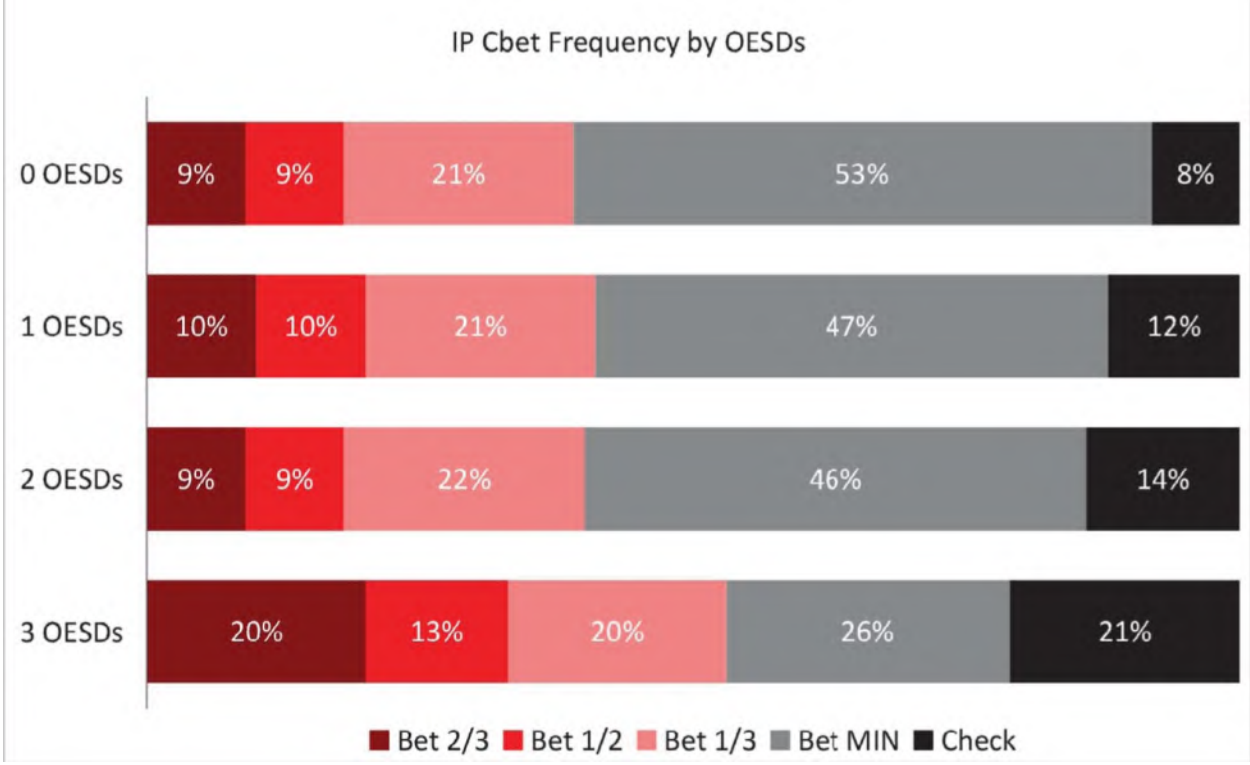


Diagram 43

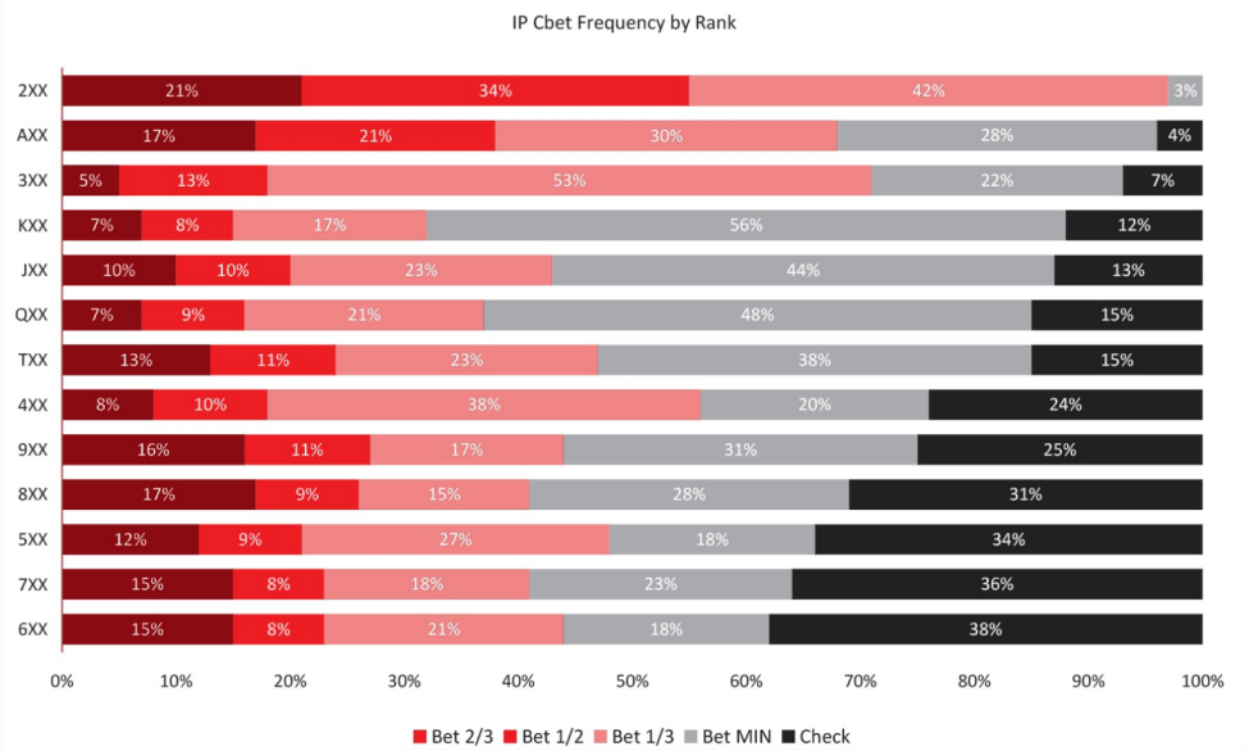


Diagram 44

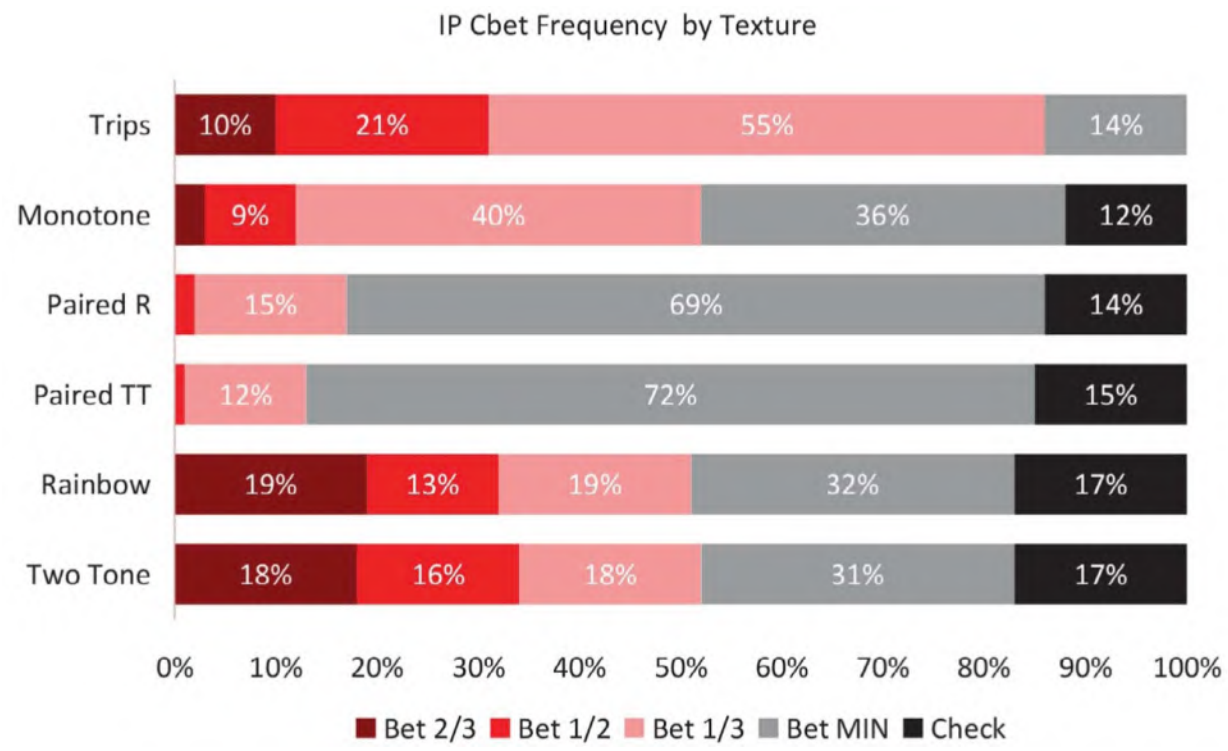


Diagram 45

Diagram 45 shows how often IP should bet in terms of the flop texture. Clearly, paired boards should be frequently min-bet. This will be examined in greater detail in the forthcoming sections.

Flop C-betting by Structure

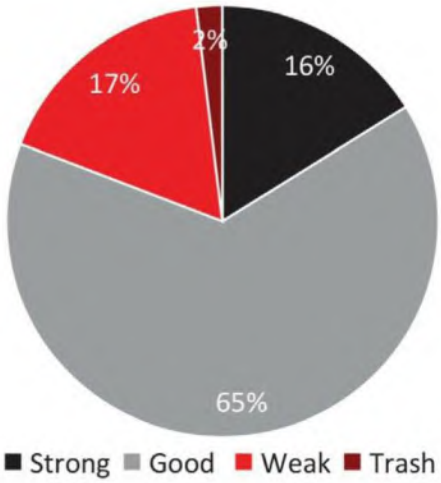
The flop structure is one of the key characteristics that drives post-flop play as the strategies differ drastically if the flops feature trips, are paired, or are unpaired.

Trips are by far the absolute best flops for IP, who can capture on average 81% of the pot on this texture. Paired boards, on the other hand, give the BB a lot of strong hands, polarizing their range and allowing them some counterplay. This range polarization is one of the main reasons why betting very small is optimal on paired boards. Small bets force the BB to reveal a lot of information about their holding, as there are a lot of trash and weak hands the BB has to fold, regardless of IP's bet-size, and IP loses the minimum when having to bet/fold the flop with the bottom of their range.

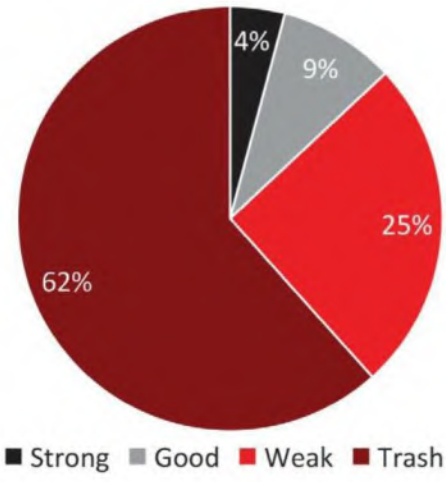
In general, small bets are preferred when IP's range has this type of depolarized distribution with the bulk of hands being good, but not great, and a low frequency of trash and weak hands. In situations where IP's range distribution is more polarized with a bigger proportion of strong,

weak and trash hands, bigger bet-sizes are used more often.

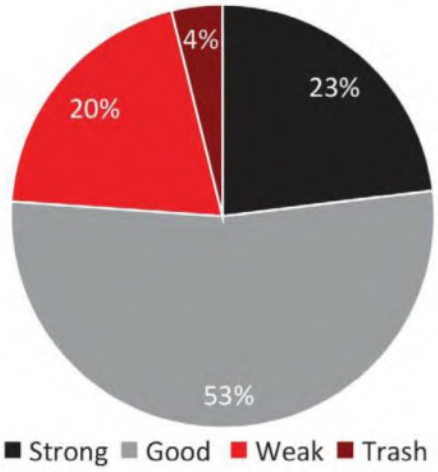
IP EQB on Trips



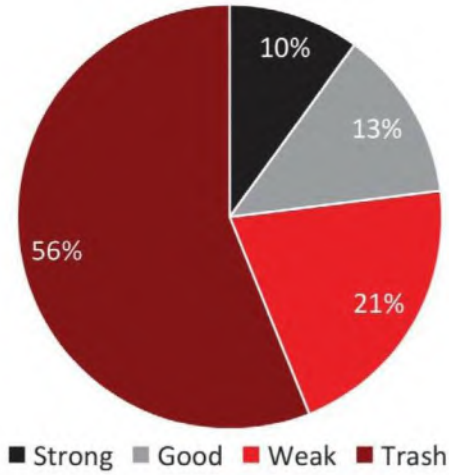
BB EQB on Trips



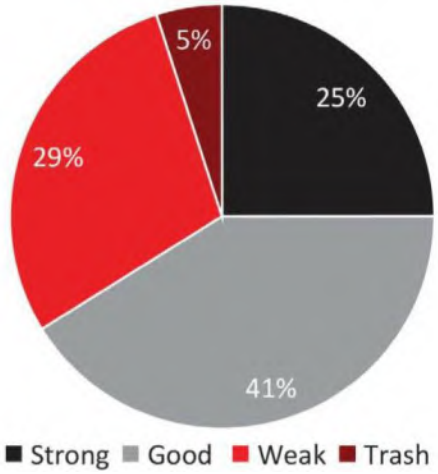
IP EQB on Paired Flops



BB EQB on Paired Flops



IP EQB in Unpaired Flops



BB EQB Unpaired Flops

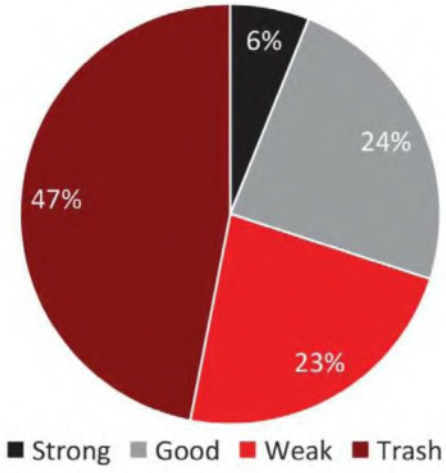


Diagram 46

Structure	% Total	EQ	EV	EQR
Trips	0.24%	64%	81%	126%
Paired	16.94%	61%	68%	112%
Unpaired	82.82%	59%	69%	116%

Table 111: IP Metrics by Flop Structure

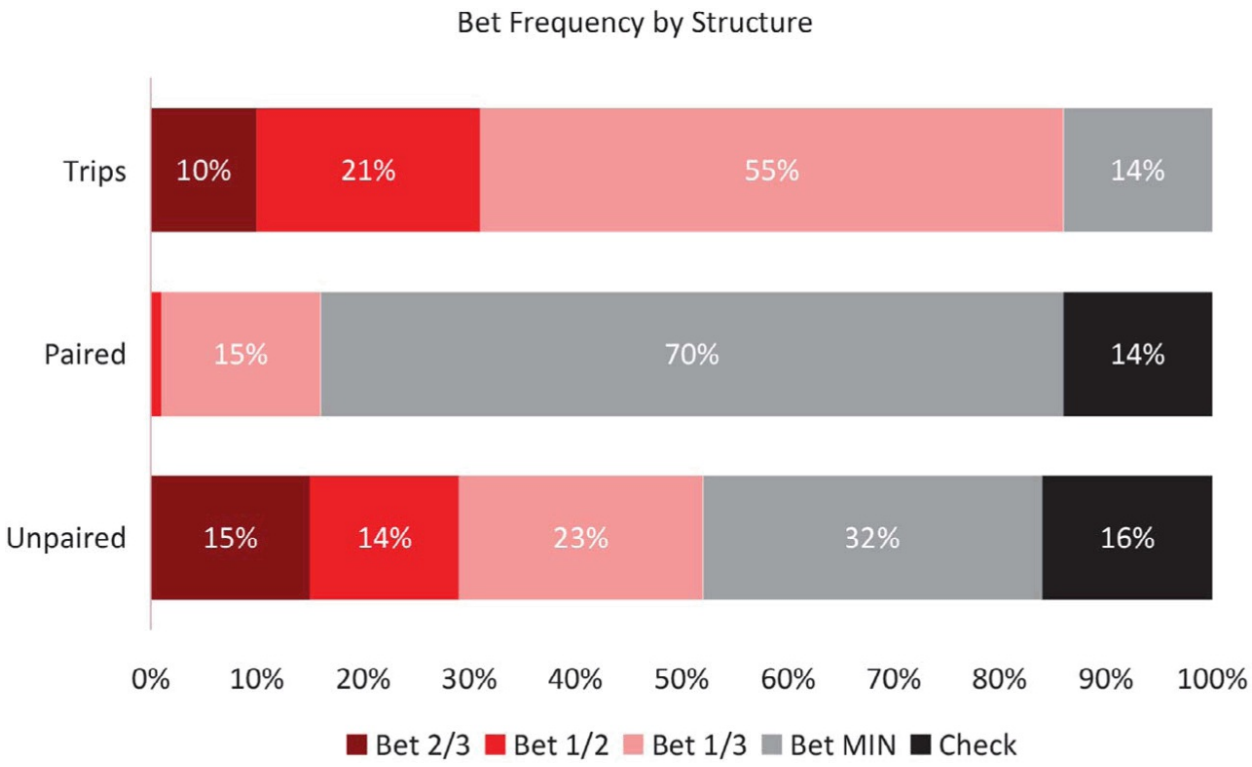


Diagram 47

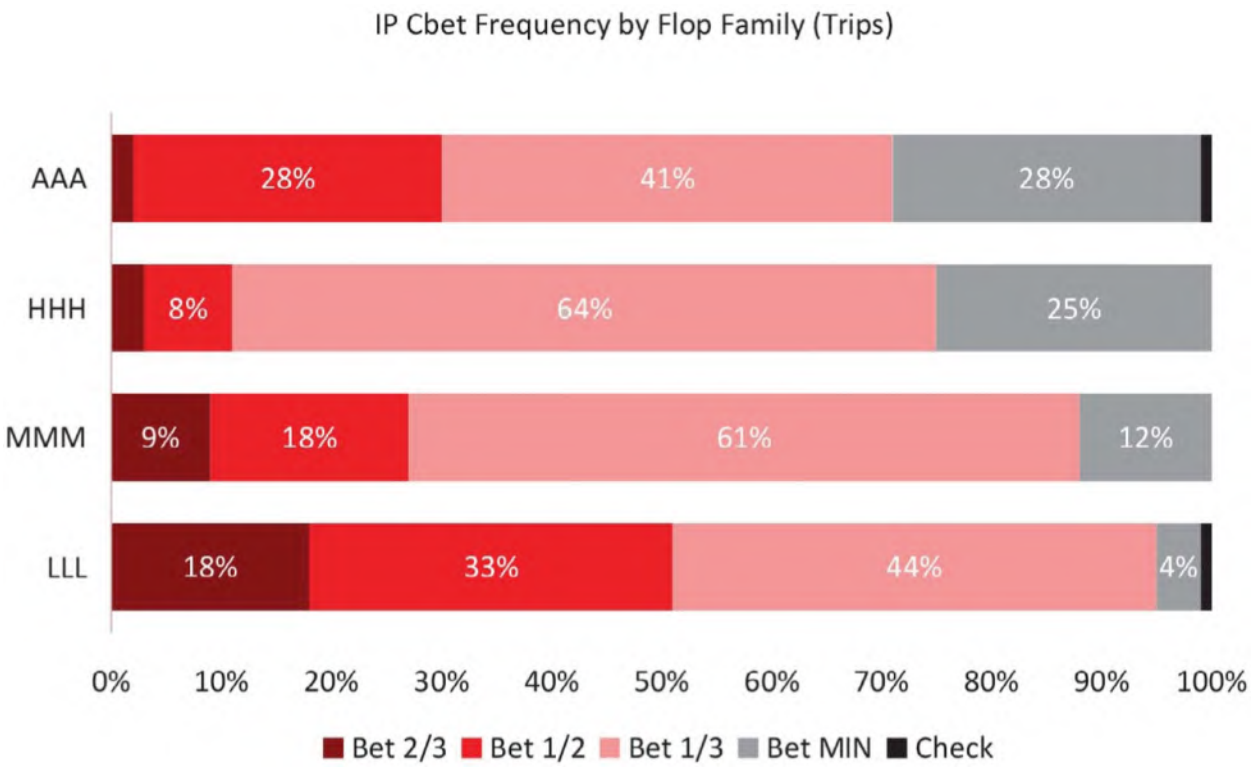


Diagram 48

On flops featuring trips, there is a clear pattern of bigger bet-sizes being used more often on the lower ranks, while 1/3-pot is the most frequently seen bet-size.

On paired flops, min-betting is clearly the preferred bet-size for most flop ranks, although 1/3-pot is preferred on flop families AAM, AAL and LLL, 1/2-pot is seldom used, while 2/3-pot is never used. The most checked families are MMH, HHA, LLM, LLH, LLL, MMM, MML and LLA. As expected, flops with the paired card being of low or middle rank tend to benefit the BB more than IP, and so they get checked more often than flops that contain a paired high card or an ace.

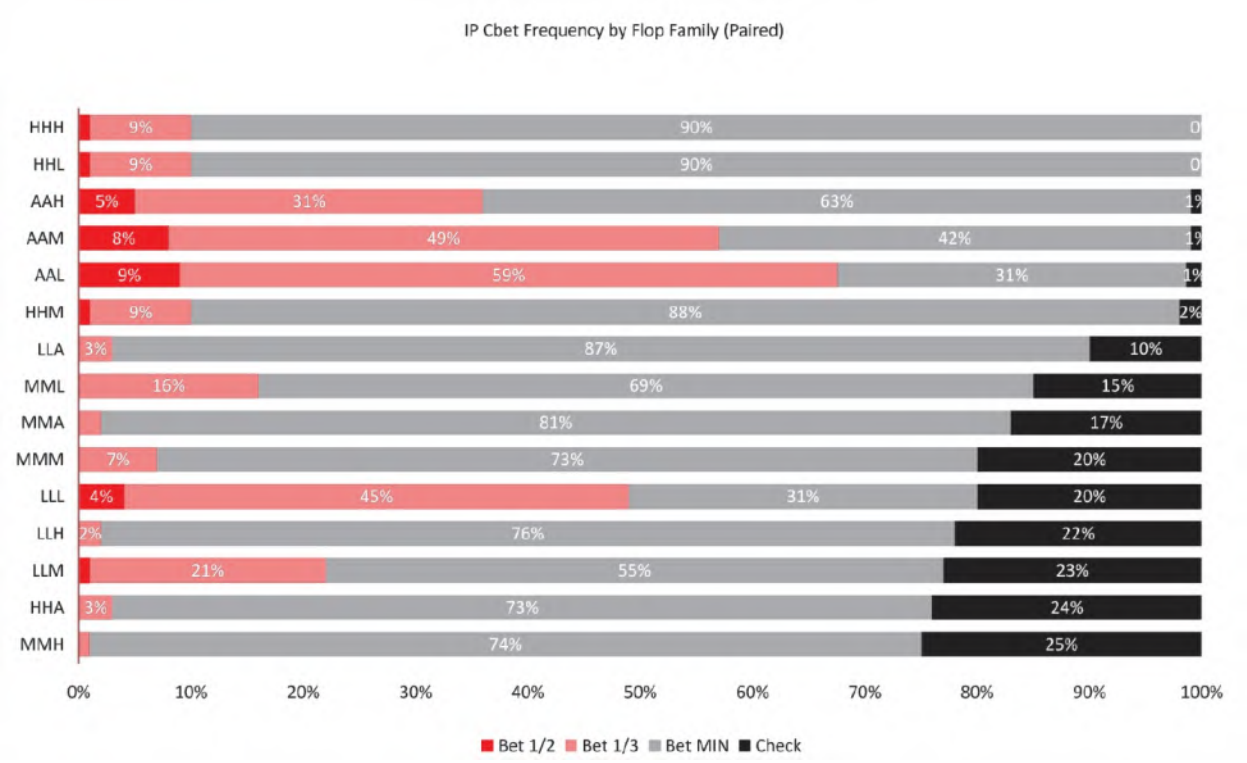


Diagram 49

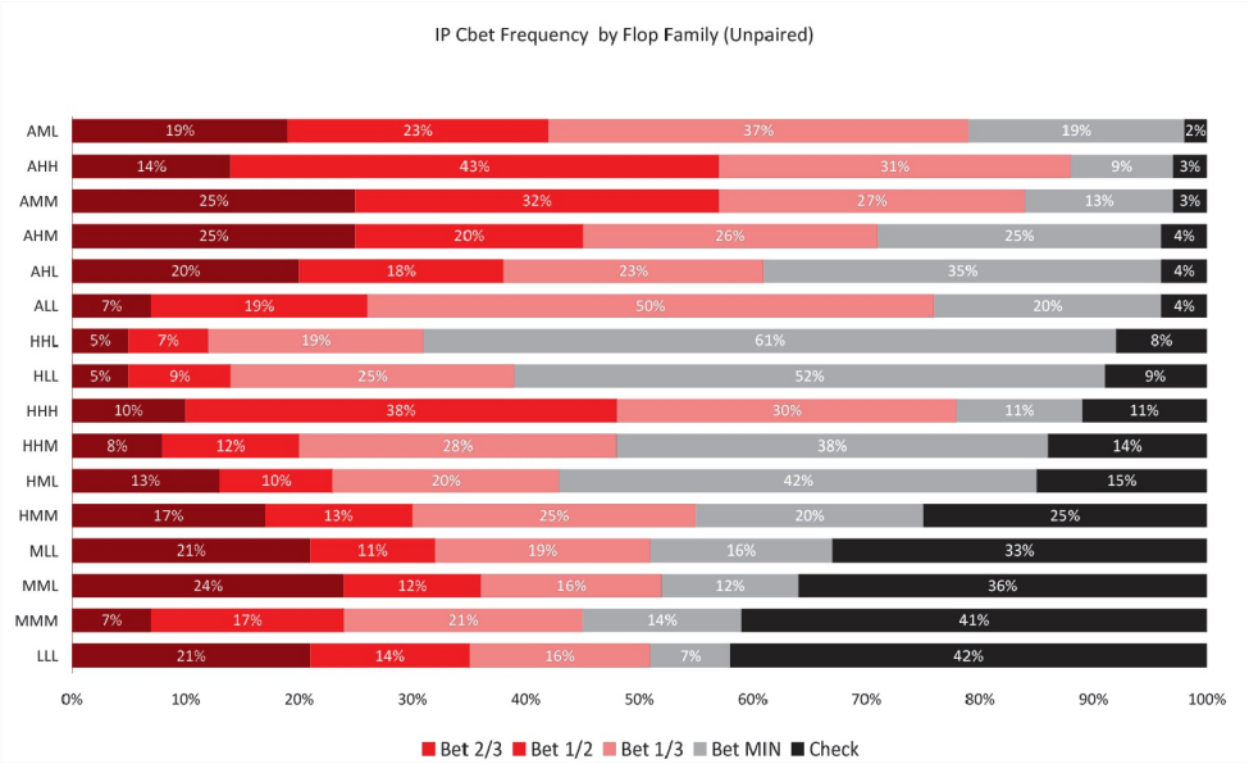


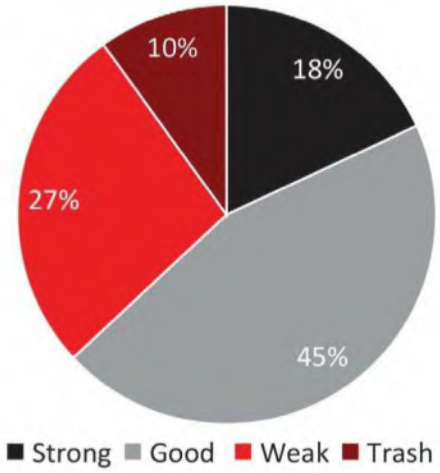
Diagram 50

On unpaired flops, the least c-bet flop families are LLL, MMM, MML, MLL and HMM. We still see a lot of bet-size mixing, so we have to look deeper into the unpaired flop textures to get a better idea of how to approach them.

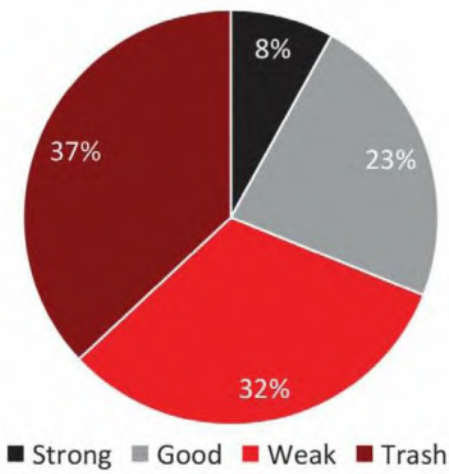
Flop C-betting by Texture (Unpaired Flops)

Unpaired flops make 82.82% of all flops. In this section, we will look into the different textures of unpaired flops and how they affect the players' range distributions and flop strategies.

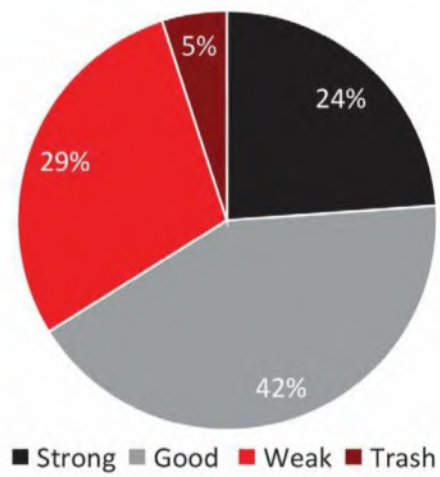
IP EQB in Monotone Flops



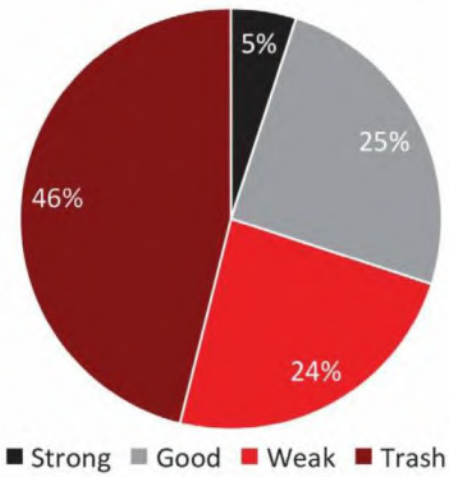
BB EQB Monotone Flops



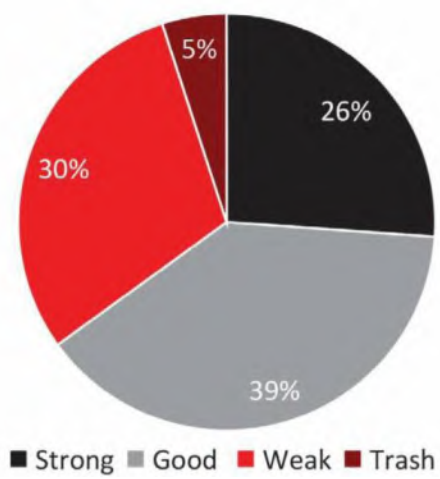
IP EQB Two Tone Flops



BB EQB Two Tone Flops



IP EQB Rainbow Flops



BB EQB Rainbow Flops

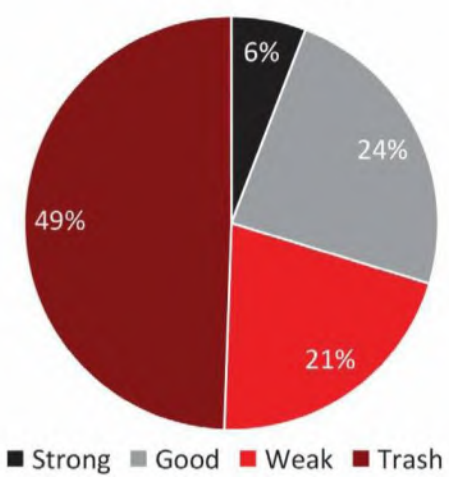


Diagram 51

IP	% Total	EQ	EV	EQR
Monotone	5%	58%	66%	114%
Two Tone	47%	60%	69%	116%
Rainbow	31%	60%	70%	117%

Table 112: IP Metrics by Flop Texture

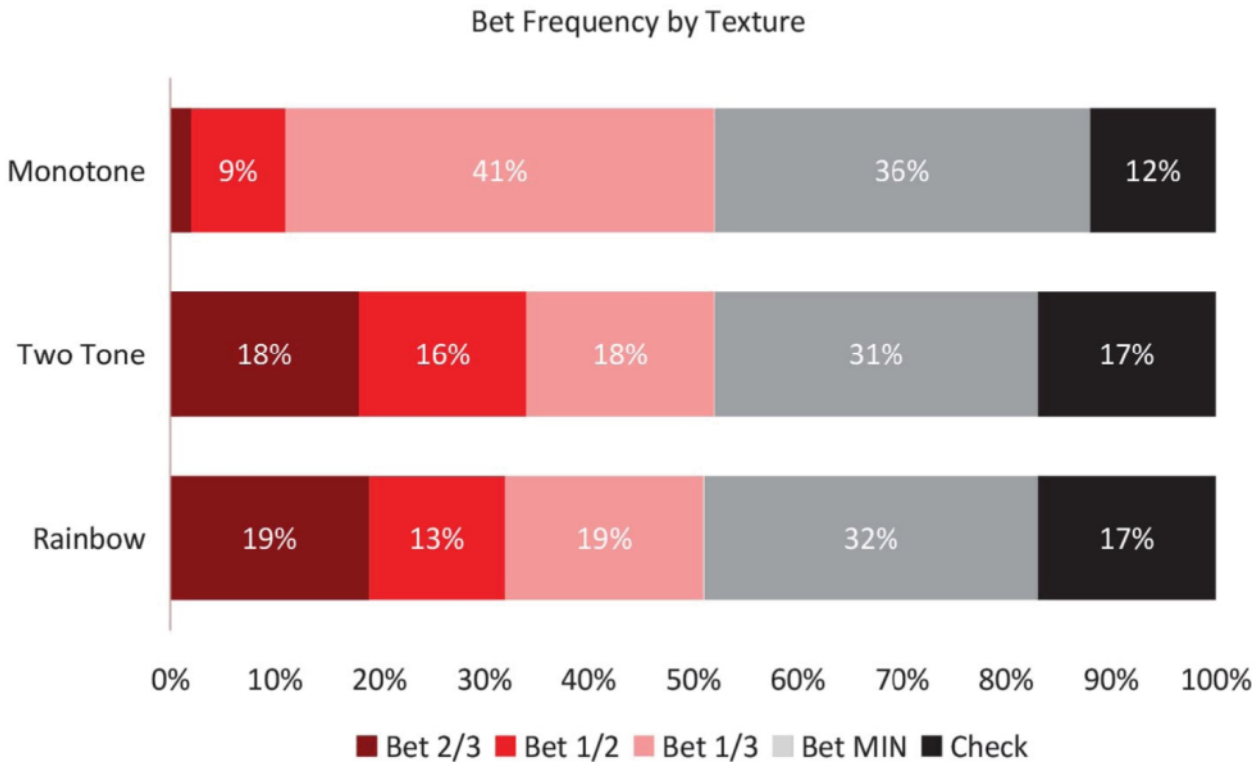


Diagram 52

Monotone flops are the most c-bet but they also have the lowest EV for IP. On this texture, IP's strong hand percentage diminishes by a large margin, while the BB's strong hand percentage increases because a lot of hands that would be trash on other textures are now flushes and a lot of IP's hands that would be strong on other textures reduce in equity. The BB's weak hands percentage also increases, as many hands that would be complete trash on other textures now have some sort of flush draw. This range distribution creates a similar situation as on paired boards, with the BB having a polarized distribution, while IP is more depolarized. For this reason, using smaller bet-sizes is preferred as they will get a lot of folds from the BB's hands that have terrible equity while not overcommitting with all of IP's good, but not great hands.

I often see players making the mistake of betting large on monotone flops, thinking that they need to protect their good hands and make the BB fold. The problem with that is that if your bet-size is too large, you force the BB to fold the weak hands that would continue against a smaller bet and will be isolating yourself against the top of their range that will either have you beat or have a ton of equity.

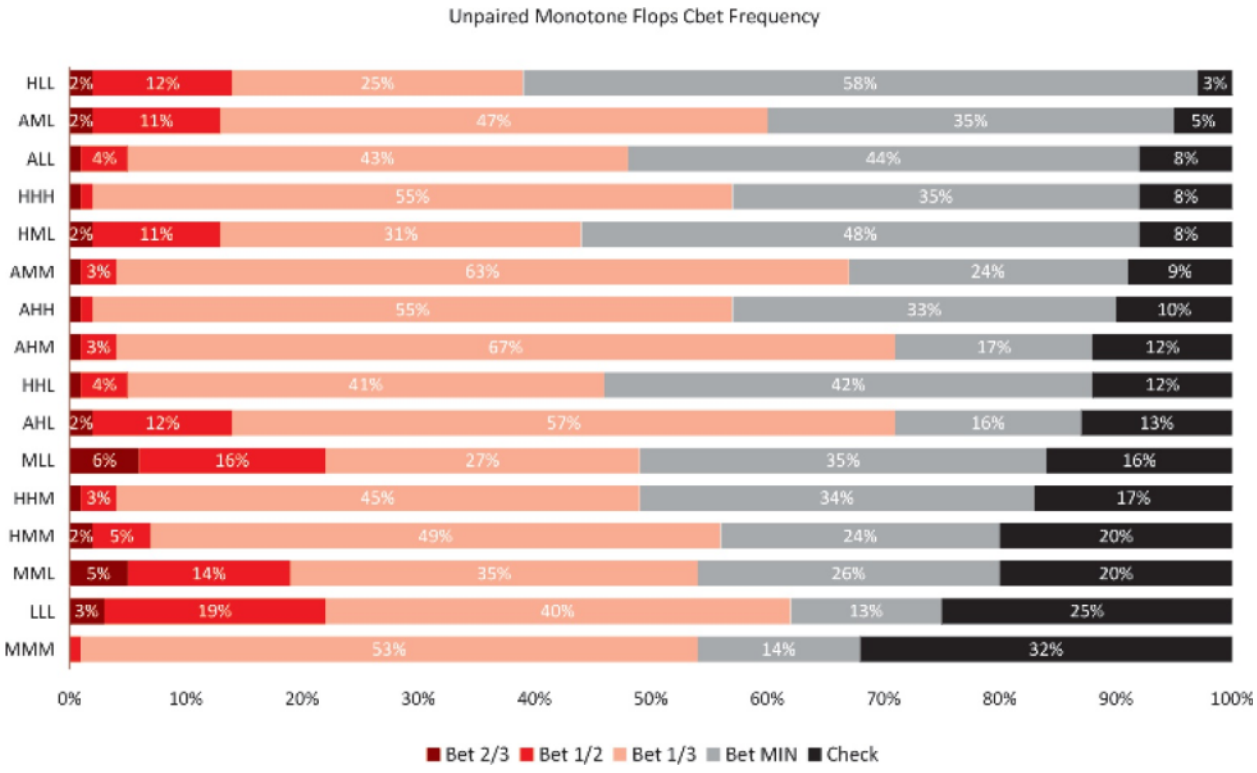


Diagram 53

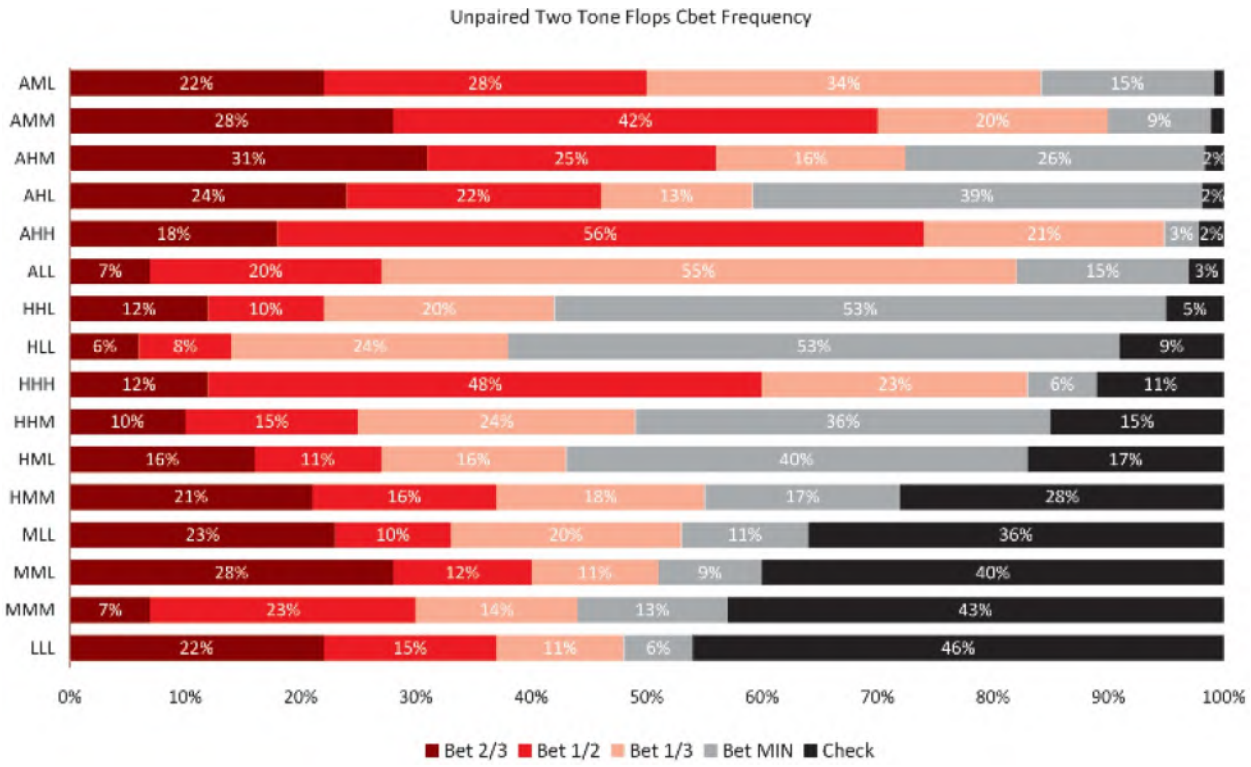


Diagram 54

The lower the ranks and the more connected the board, the less IP gets to c-bet, with MMM, LLL, MML, and HMM being the least c-bet flops. Flops with three possible flopped straights are checked 31% of the time, flops with two straights are checked 28%, flops with one straight are checked 17% and flops with zero straights are checked only 10% of the time. Stack depth also has an effect, with deeper stacks being more likely to check the flop.

We could easily simplify our strategy on monotone flops to use only 1/3-pot bet-sizes or min-bets without suffering a significant EV loss.

Again, we see the trend of lower ranks being c-bet less frequently. However, we see a big difference in the way bet-sizes are used compared to monotone flops, with bigger bet-sizes being used a lot more frequently. Again, this is a function of the way the equities are distributed on two-tone flops, with IP having 24% strong hands compared to the BB's 5%.

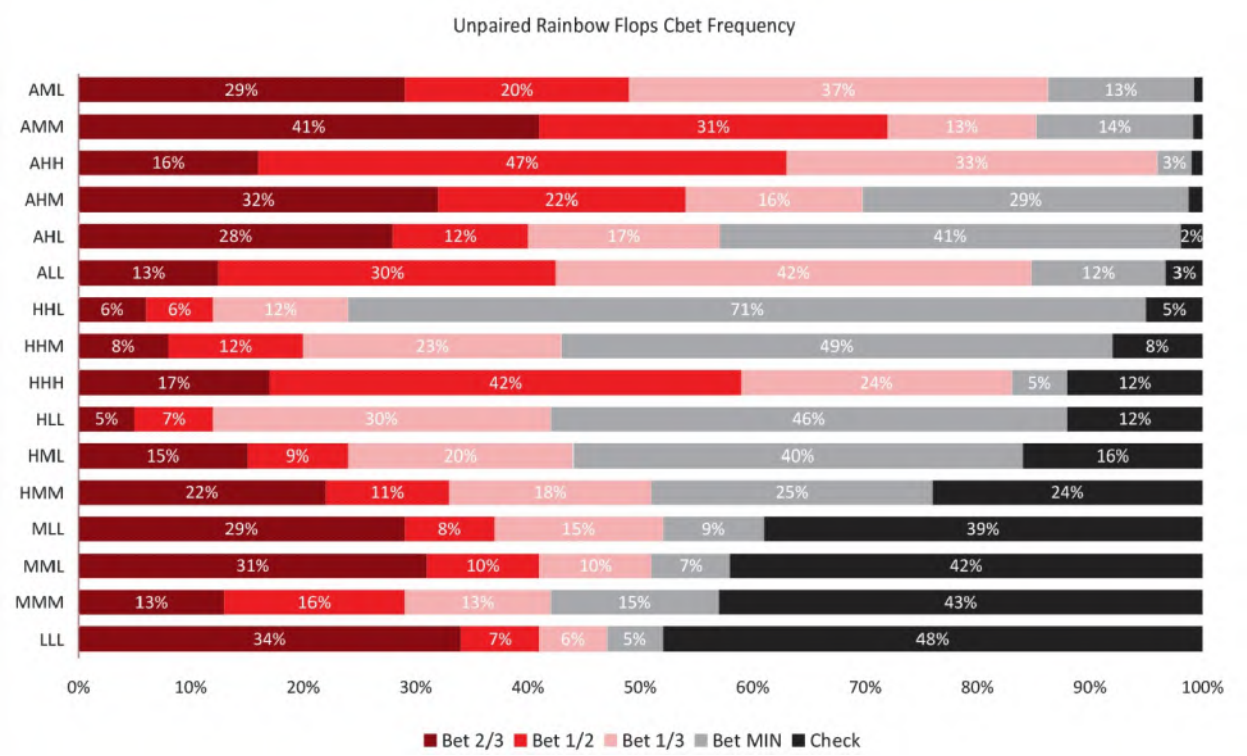


Diagram 55

On rainbow flops, IP's range advantage is even greater than on two-tone flops, which will again result in an even higher preference for larger bet-sizes. Hands that are strong on rainbow flops usually also tend to be strong on the turn and river. Conversely, on two-tone flops, the presence of possible flush draws will result in more abrupt equity shifts. The absence of flush draws on the flop also increases the percentage of the BB's trash hands that would have a flush draw on a two-tone board. For these reasons, IP will be able to triple barrel more effectively on rainbow flops and get all the money in by the river.

Developing IP C-betting Strategies

The first thing you should consider when deciding to c-bet is your opponent's skill level. If the Villain is a weak player who is completely oblivious, you can get away with doing pretty much anything you want. If you think they are likely to call your overbets across three streets very light, then you should by all means take them to value town any time you have a hand that is ahead of their calling range.

On the other hand, if you have a hand that has very little equity and bad blockers, you should either give up or bet small, trying to take down the pot right there, and be ready to give up if your

first bet is called because this type of player will simply not fold, regardless of the bet-size you choose. As with this example, there are many different situations where you should tweak your bet-size and frequencies in order to manipulate your opponent's range. The problem with making these adjustments occurs when your opponent is smart, aware and capable of counter-exploitation. Then, you need to have a solid strategy so you don't get exploited instead.

If the Villain is a good player, or at least you think that they will likely defend well on the particular flop with the ranges in play, then there are two main concepts to consider:

♦ The flop GTO c-betting frequency

♦ The c-bet-size

In this section, we focus on these two key factors and try to use them to develop our intuition so we can more effectively develop our own c-betting strategies.

All the simulations that were used to develop the data in this section had the familiar flop bet-sizes: min-bets, 1/3-pot, 1/2-pot and 2/3-pot. We can categorize flop bet-sizes into two groups according to the c-bet size that is preferred by the solver:

♦ Big bet-size: 1/2-pot, 2/3-pot

♦ Small bet-size: min-bet, 1/3-pot

We can also categorize flops according to c-bet frequency as follows:

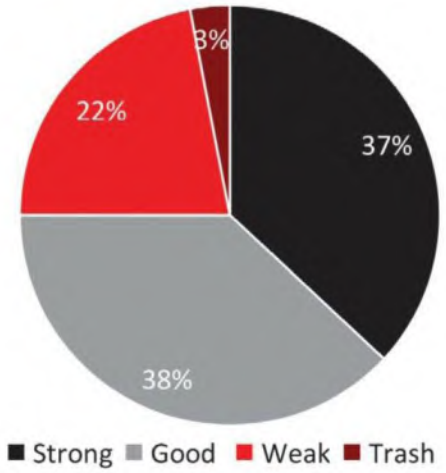
♦ High c-bet frequency flops (80%+)

♦ Mid c-bet frequency flops (60%-80%)

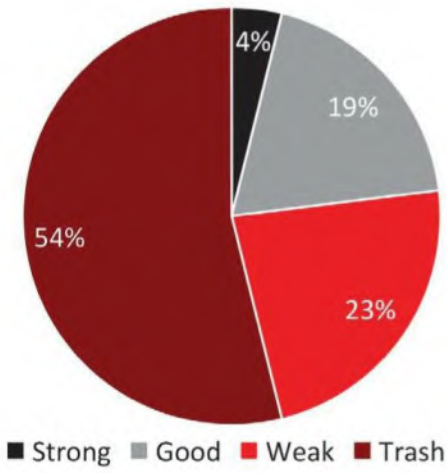
♦ Low c-bet frequency flops (less than 60%)

In poker, it is rarely the case that something is true 100% of the time, and the equity buckets system is no exception. Still, we can use the EQB diagrams to get a good idea of how the players' equity distributions affect post-flop play by studying the EQB in the previously used flop categories.

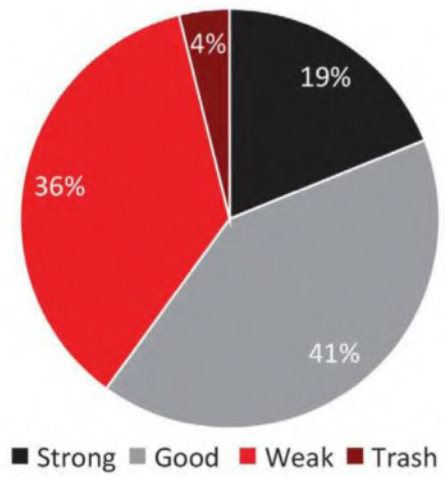
High Cbet % (IP)



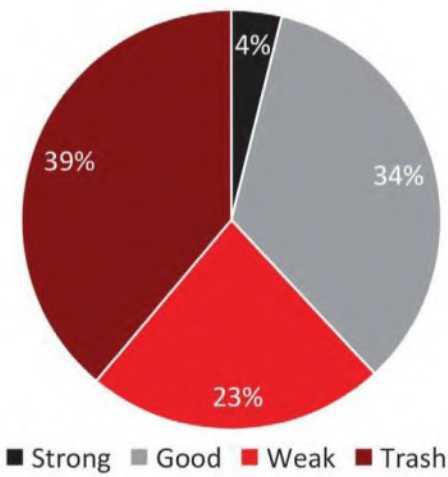
High Cbet % (OOP)



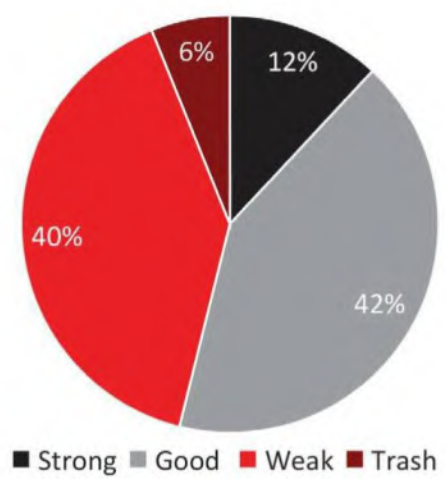
Mid Cbet % (IP)



Mid Cbet % (OOP)



Low Cbet % (IP)



Low Cbet % (OOP)

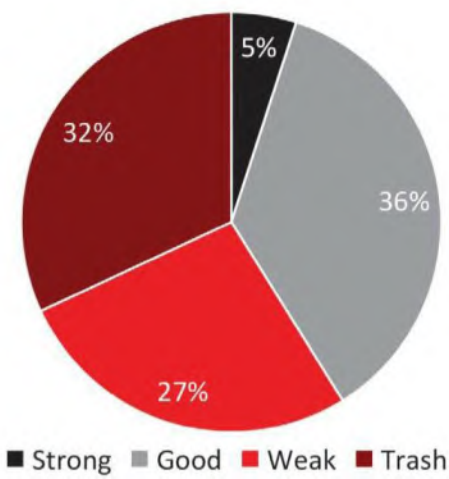
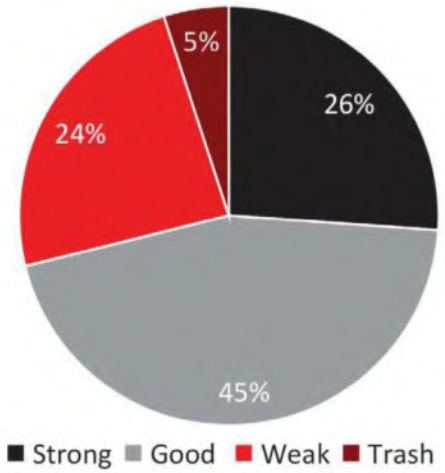


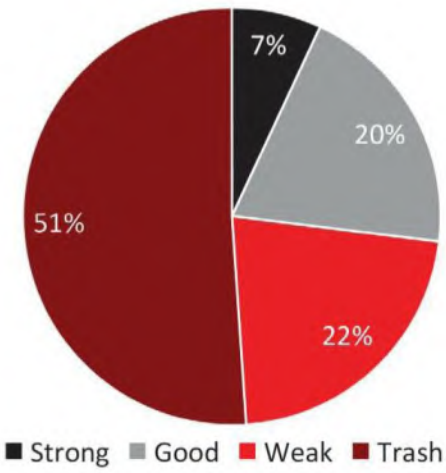
Diagram 56: Big Bet-size: Average Flop Equity Buckets

In general, when a big bet-size is used by IP, the BB has the most depolarized range with about 4-5% strong hands and a higher number of good hands, 19-36%. When a small bet-size is used, the BB has 7-9% strong hands (twice as many strong hands) and a lower number of good hands, 20-27%. So, IP sizes up when OOP has many hands that can potentially call the flop, and sizes down when OOP potentially has more raising hands.

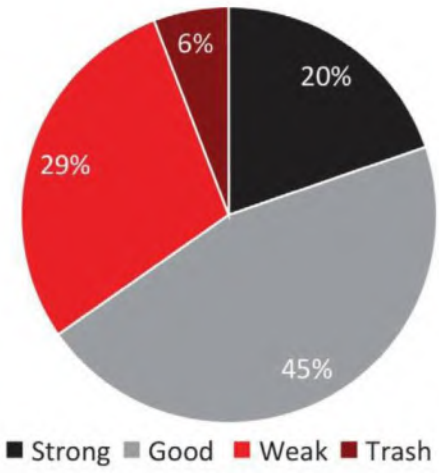
High Cbet % (IP)



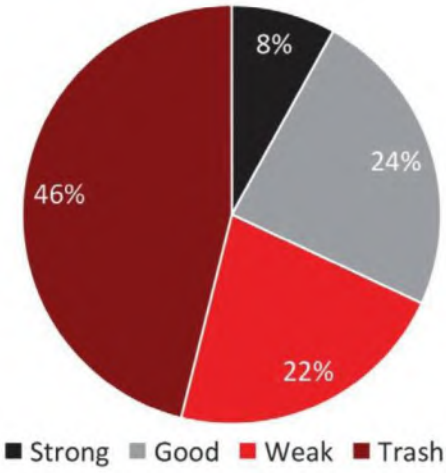
High Cbet % (OOP)



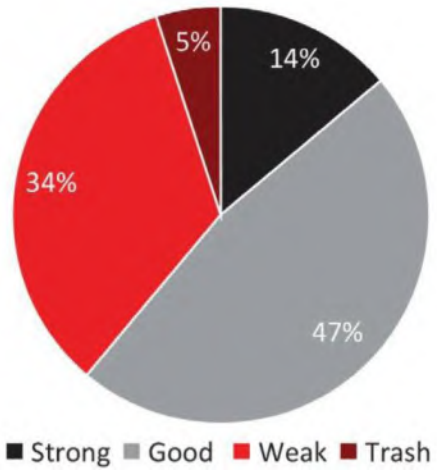
Mid Cbet % (IP)



Mid Cbet % (OOP)



Low Cbet % (IP)



Low Cbet % (OOP)

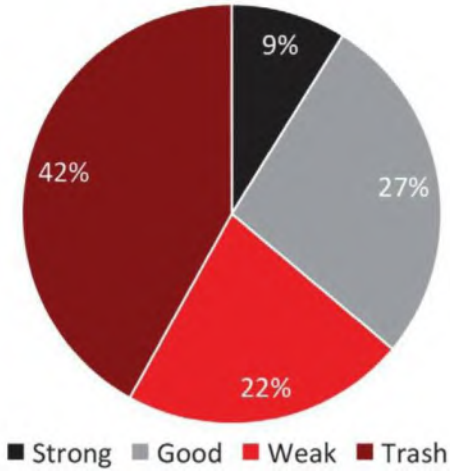


Diagram 57: Small Bet-size: Average Flop Equity Buckets

Another interesting trend is how IP's c-betting frequency increases as more trash hands are in the BB's range and decreases as the IP's range becomes more depolarized. When the number of strong hands in their range decreases, the number of good and weak hands in their range increases.

In practice, on 80%+ c-bet flops, you can get away with c-betting 100% of the time with little to no EV loss, even against a minimally exploitative opponent. Due to IP's massive range advantage, there is little the Villain can do to attack the flop c-bets.

On mid frequency c-bet flops, IP's range still dominates the BB, but the ranges are now much closer, as IP's range becomes more depolarized by having fewer strong hands and more weak hands than on high c-bet flops, while the BB's range gets stronger. Because of this shift in the range composition, IP cannot get away with c-betting at a high frequency without it costing EV, even against weak players, as their ranges hit these flops too well, making it easy for them to defend against flop bets. Instead of betting a merged range, IP splits their range, checking back good, but not great hands that benefit from keeping the pot small and seeing a free turn card at a high frequency, while c-betting a more polarized range, which results in bigger bet-sizes becoming more dominant.

Playing turns after checking back the flop can be challenging and, for this reason, I frequently hear players come up with excuses to bet hands they should be checking back on the flop so they don't have to deal with playing difficult turns. One of the most typical arguments is that the bet is a so-called "information bet". Some players are eager to make a flop bet with a weak hand that would benefit from checking back and playing a small pot, only to get raised off the pot in situations where the BB is likely to x/r the flop. Or, even worse, they will call the flop x/r only to fold on a turn bet 100% of the time when they fail to improve. This is a massive mistake that amateurs and even many pros make on a regular basis simply because they want to avoid losing the "betting lead". They are happy to put more money into the pot just to fold to aggression so they can feel good about themselves for making a "good fold".

Playing poker is easier when you have the stronger range and you are the one making bets, putting your opponents to the test, but that cannot be an excuse for making -EV plays by overplaying your hands.

Poker is not about trying to win every single hand you play by force, but instead about making the highest EV play every time.

Sometimes the highest EV play is to simply give up.

Learning how to balance your ranges so you are not an easy target, and being selectively aggressive and smart, is what makes the difference between a rookie and a top player.

General IP C-bet Guidelines

- ♦ You don't need to know the exact range composition combo by combo. All you need to make educated decisions is to have a good idea of the composition of each player's equity buckets.
- ♦ If your opponent has a lot of trash in their range, you should c-bet at a high frequency and expect to get many folds. If they have very few strong hands compared to you, you should size up!
- ♦ High c-bet % and big bet-size flops are the absolute best flops for IP. They allow for aggressive play and you should expect to capture most of the pot.
- ♦ Low c-bet % and small bet-size flops are the best flops for the BB. Equities run close and you should be cautious, generally betting small and at a low frequency.
- ♦ The types of hands that the solver likes to check back on the flop are generally the same. What changes is the frequency they are checked.
- ♦ Bet-folding high equity hands on the flop is a disaster. If your range is not strong enough to c-bet 100% without risking being x/r at a high frequency, you should split your range, c-betting a more polarized range and checking back good and weak hands that benefit from taking a free turn.
- ♦ If you do have a checking range on a given flop, check back strong hands that block your opponent's continuing range, particularly if, on that flop, you are likely to get many folds.
- ♦ If you expect your opponent to fold a lot or raise your bet, you should bet small at a high frequency, and if you expect them to call a lot, you should size up.
- ♦ Don't put yourself in areas of the game tree where you are not comfortable. It is a completely different thing to ask yourself how the solver would play a tricky spot and to ask what the best play you can think of right now is.
- ♦ It's better to have a plan, even a simple plan, than have no plan at all.

♦ In multi-way pots, blockers are more important than raw hand strength.

♦ Generally, play passively in multi-way pots. Don't bet draws too often unless they are to the nuts.

♦ Never think about a hand in a vacuum. Always think about the context.

♦ Hands with backdoor equity and no showdown value generally work well as semi-bluffs.

♦ If you have a checking range, make sure to check back strong hands with some frequency so you don't get easily exploited by aggressive players stabbing at the pot after you checked.

♦ If you are unsure about the flop strategy with your range, you can default to c-betting 1/3-pot in most short and middle stack situations.

♦ If you are unsure whether you should bet or check your hand, ask yourself what would happen if you are raised. If your hand hates being raised and you are likely to face a x/r, then you should probably check.

♦ If the BB does not have a donk betting range on good donking flops, you should c-bet less often than equilibrium suggests because you will get x/r more often.

♦ If your hand can get value across three streets, it is almost always ideal to start by betting the flop.

♦ Don't try to get recreational players off top pair. More often than not, they will not fold it.

The Way Ahead or Way Behind Situation

Sometimes IP's range is so strong compared to the BB's range that, even if they could profitably c-bet 100% and get a lot of folds, the strategy involves checking back the flop at a high frequency. This happens on flops where BB's range is extremely polarized to strong hands and a lot of trash with little in between.

Example
Board: A♠T♥T♦
Situation: BB vs UTG
Stack depth: 30bb

IP EQB: 57% strong hands, 37% good, 5% weak and 1% trash
BB EQB: 7% strong, 12% good, 0% weak and 81% trash.

This situation is commonly known as *way ahead or way behind* because your opponent will either have a monster or little to nothing, without much in between. In this set-up, IP wants to check back the flop with many good hands for pot control, alongside a big chunk of strong hands as traps. IP also wants to c-bet all trash hands and most weak hands, balanced with the remaining strong and some good hands. This allows IP to often win the pot uncontested on the flop with trash while being able to bluff-catch effectively on future streets after checking back the flop.

When facing a x/r, you should always consider your opponent's range and your hand vs range equity. If the Villain is likely to x/r the flop less than equilibrium suggests, they will probably be missing the optimal bluff. Their range will be heavily skewed towards strong hands and your overall equity will be a lot lower than you would expect it to be. If that is the case, you can exploit the Villain by over-folding the flop. Even if they bluff you once in a while, their frequencies are so far off to the point that it is not worth the risk of continuing with middle strength hands. Depending on the Villain, you can even lay down some strong hands you would never consider folding against someone else.

If Villain's range is skewed towards draws, then you can 3-bet aggressively with your good and strong hands that can benefit from protection. If the Villain's range is polarized to strong hands or bluffs, your range will play better as a bluff-catcher. Let them keep putting money in with bluffs and don't raise back with medium strength hands.

IP C-bet Examples

Flop Strategy Example 1

High c-bet % and big bet-size: BB vs UTG on A♥Q♦3♠ (40bb)

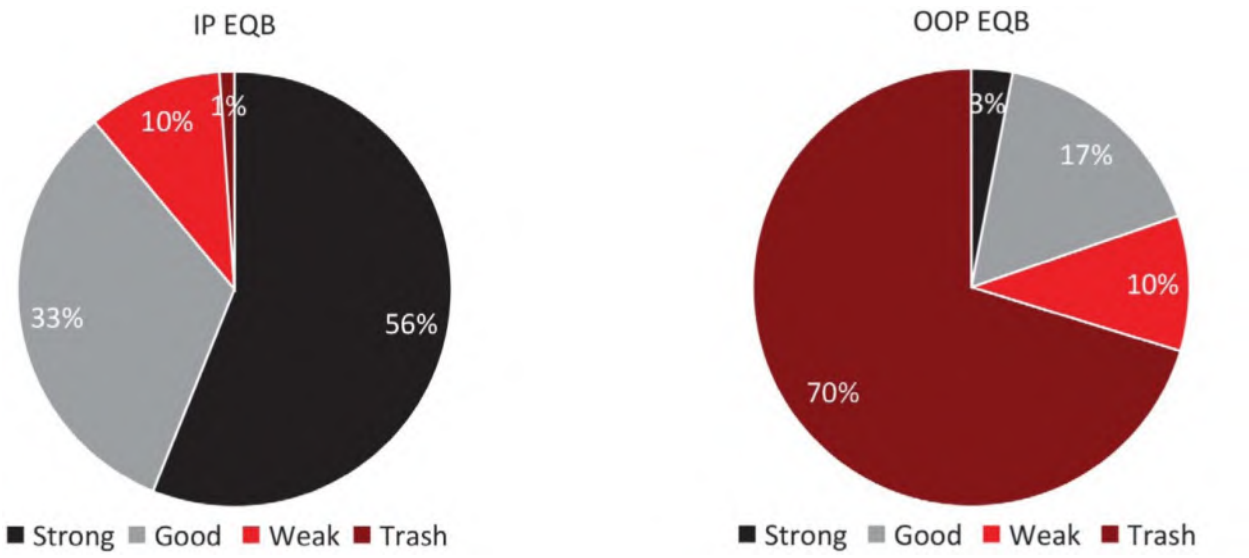


Diagram 58: High c-bet % and Big Bet-size: BB vs UTG on A♥Q♦3♠ (40bb)

If we give IP the option to use a 120% overbet, the solver will use it 14.45% of the time, although this does not generate any extra EV to IP. On the other hand, simplifying the strategy to c-bet 100% for 1/3-pot bet-size loses 1.07% of the pot, or 6.6bb/100. Simplifying the strategy to c-bet 100% using the 2/3-pot bet-size retains all of IP's EV.

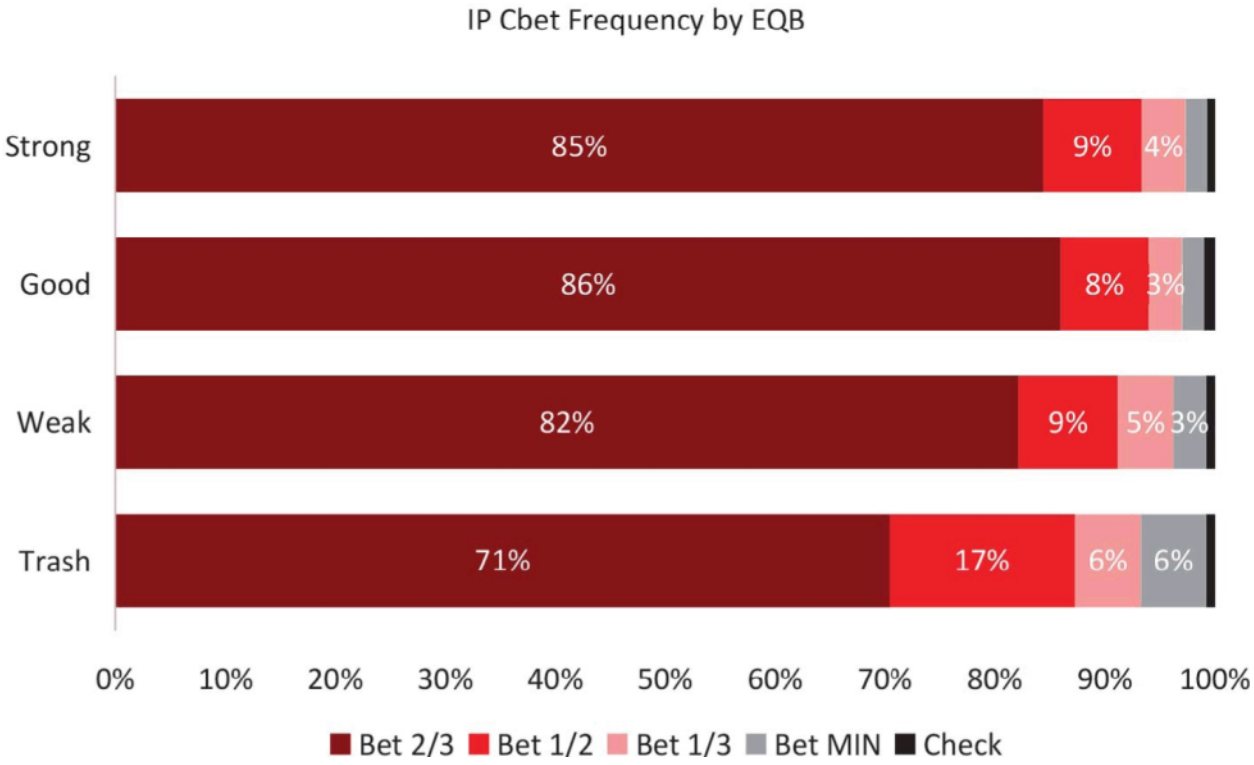


Diagram 59

Hand	% of Range	Equity	EV	EQR	Bet 2/3	Bet 1/2	Bet 1/3	Bet Min	Check
Sets	3.5%	96%	172%	179%	67.5%	13.0%	9.6%	6.9%	1.0%
Two Pair	6.3%	93%	153%	165%	87.6%	9.5%	2.2%	0.6%	0.2%
Top Pair	31.8%	86%	107%	124%	88.9%	7.4%	2.3%	1.1%	0.4%
Pocket 1-2 (KK)	3.5%	77%	68%	89%	65.8%	14.7%	10.0%	6.7%	2.8%
Second Pair	11.9%	77%	73%	94%	82.6%	10.0%	3.9%	2.3%	1.2%
Pocket 2-3 (66-JJ)	21.1%	61%	55%	90%	84.6%	8.1%	3.6%	2.5%	1.1%
Gutshot	10.7%	55%	68%	123%	87.9%	7.8%	2.4%	1.2%	0.7%
King High	4.2%	47%	52%	111%	76.5%	10.0%	0.6%	5.7%	1.2%
Air	6.5%	37%	53%	144%	83.4%	9.6%	4.0%	2.6%	0.5%
Full Range	100.0%	72%	85%	119%	84.6%	8.8%	3.6%	2.2%	0.8%

Table 113: UTG C-betting Range Breakdown on A♥Q♦3♠

On A♥Q♦3♠, UTG has all very strong hands, such as AA, QQ and AK, while the BB would 3-bet AA and QQ all the time and AK most of the time. This lack of nutted hands in the BB's range allows IP to bet big across multiple streets, over-realizing the 72% equity and capturing 85% of the pot.

Facing a Min x/r

On this flop, IP has a massive range advantage and, at equilibrium, should only face a flop x/r about 5% of the time. OOP's x/r range contains hands such as 33, AQ, A3, Q3, AJ, a few AT-A7, and bluffs such as gutshots and some bottom pair plus a BDFD and BDSTD.

UTG's typical response should be to fold about 30% of their range, including most pocket pairs, K-high without a gutshot and pure air. UTG's 3-bet range contains hands such as AK, AJ, a small frequency of AQ, and about 5% of sets for value, plus some KJo, QJs and QTs without a BDFD and about half of JJ as bluffs. 52% of UTG's range calls vs the x/r and plays the turn including any top pair, middle pair and gutshots.

Flop Strategy Example 2

High c-bet % and small bet-size: BB vs UTG on Q♥J♥T♥ (40bb)

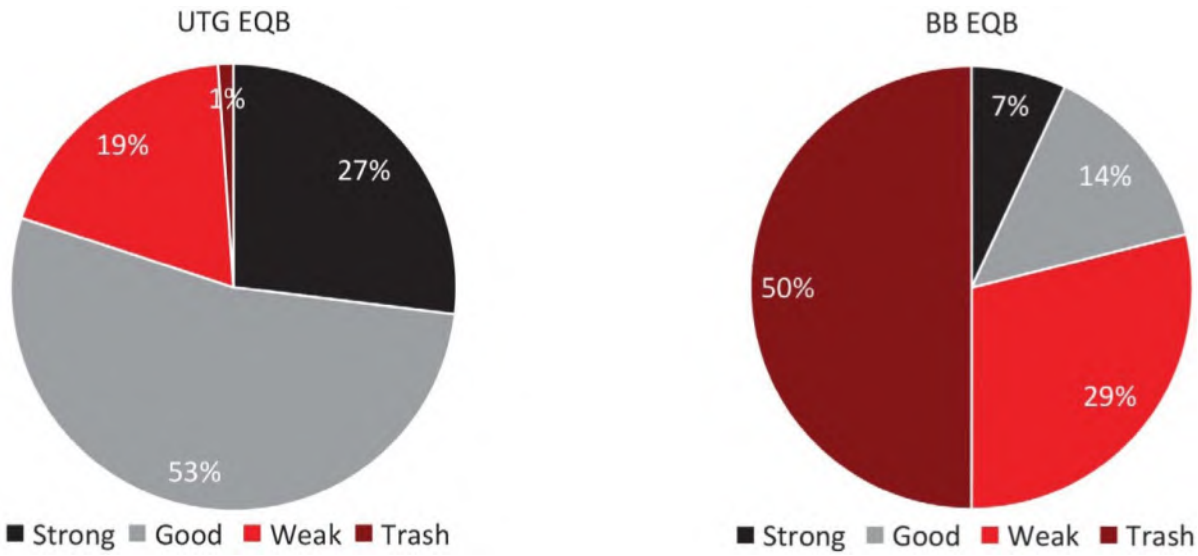


Diagram 59: High C-bet % and Small Bet-size: BB vs UTG on Q♥J♥T♥ (40bb)

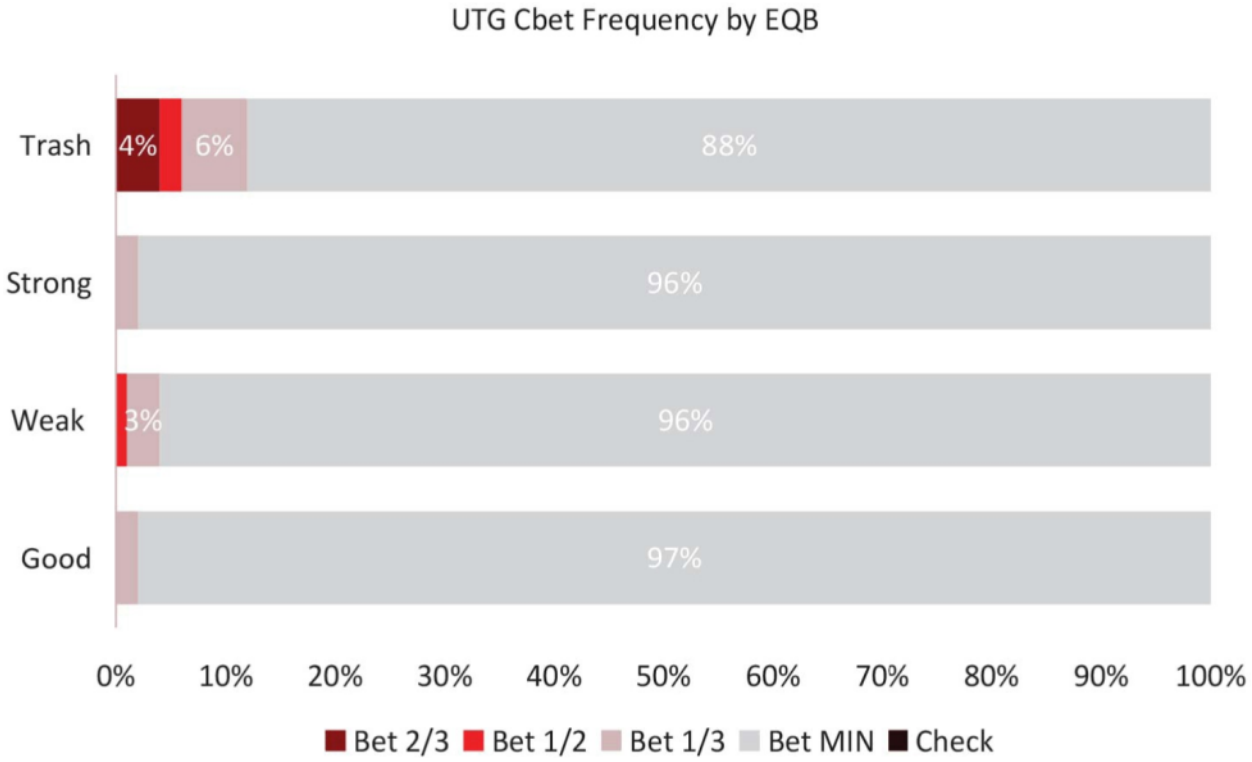


Diagram 60

On Q♥J♥T♥, UTG has a substantial range advantage, so they would like to c-bet at a high frequency, but the BB's range is too polarized, with many hands that would not be able to continue on the flop if UTG used a big bet-size. At the same time, BB has many strong hands that will be happy to continue vs a big bet-size. So, by betting big UTG would be making the

BB's life easier, allowing them to correctly fold weak hands and continue with a very strong range. If instead, UTG bets the minimum, this will lure the BB in with many weak hands that UTG dominates, keeping their range wider on future streets.

Hand	% of Range	Equity	EV	EQR	Bet 2/3	Bet 1/2	Bet 1/3	Bet Min	Check
Straight Flush	1.1%	100%	215%	215%	0.1%	0.1%	1.0%	98.4%	0.4%
Flush	4.6%	97%	191%	197%	0.6%	0.7%	2.4%	96.1%	0.3%
Straight	10.3%	82%	101%	123%	0.5%	0.5%	2.6%	96.0%	0.4%
Sets	5.2%	74%	101%	136%	0.3%	0.5%	2.3%	96.5%	0.4%
Two Pair	5.2%	65%	70%	107%	0.2%	0.2%	2.4%	96.6%	0.6%
Over Pair	3.4%	67%	57%	86%	0.2%	0.3%	1.3%	97.6%	0.7%
Top Pair	11.6%	84%	55%	84%	0.2%	0.2%	1.1%	98.0%	0.5%
Second Pair	10.1%	79%	48%	79%	0.3%	0.3%	1.6%	96.8%	1.0%
Third Pair	9.7%	56%	42%	79%	0.4%	0.4%	2.1%	96.5%	0.6%
Underpair	3.5%	35%	34%	96%	0.6%	0.7%	2.5%	95.9%	0.3%
Combo Draw	14.7%	77%	96%	125%	0.3%	0.4%	1.8%	97.0%	0.5%
Flush Draw	3.5%	55%	56%	102%	0.1%	0.2%	1.1%	97.8%	0.9%
OESD	6.5%	46%	42%	93%	0.3%	0.4%	1.6%	97.3%	0.5%
Gutshot	10.1%	38%	36%	94%	0.4%	0.7%	3.1%	95.2%	0.5%
Air	0.5%	15%	32%	209%	4.6%	2.2%	6.3%	86.8%	0.2%
Full Range	100.0%	64%	72%	112%	0.4%	0.4%	2.0%	96.7%	0.6%

Table 114: UTG c-betting Range Breakdown on Q♥J♥T♥

The strategy on this flop can be simplified to min-bet 100% with no EV loss. Many times, when people see all the small frequencies being used, they freak out, thinking that playing with that level of detail is impossible, and they are right. Only a solver would be capable of that kind of mixing but, as we saw in the post-flop bet-sizing section, we don't need to use multiple bet-sizes, as a single bet-size will retain virtually all the strategy's EV.

Facing a 50% Pot x/r

The BB x/r range on this flop includes many strong hands such as flushes, straights, sets and two pair, alongside flush draws and straights draws and not too much pure air.

UTG's response to a flop x/r on this texture is to almost never 3-bet, folding about 35% of the time and calling the remaining 65%. UTG's continuing range includes pretty much all hands that are two pair or better, a pair with a straight draw and pretty much any hand that has a flush draw.

Flop Strategy Example 3

Mid c-bet % and big bet-size: BB vs UTG on 9♥8♥4♦ (40bbs)

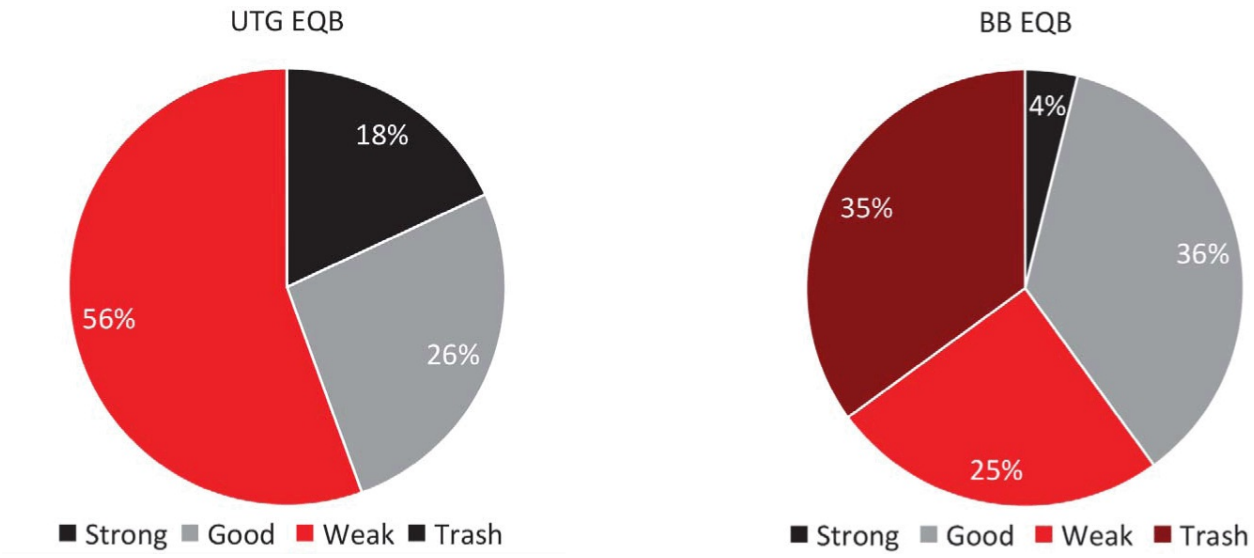


Diagram 61: Mid c-bet % and Big Bet-size: BB vs UTG on 9♥8♥4♦ (40bbs)

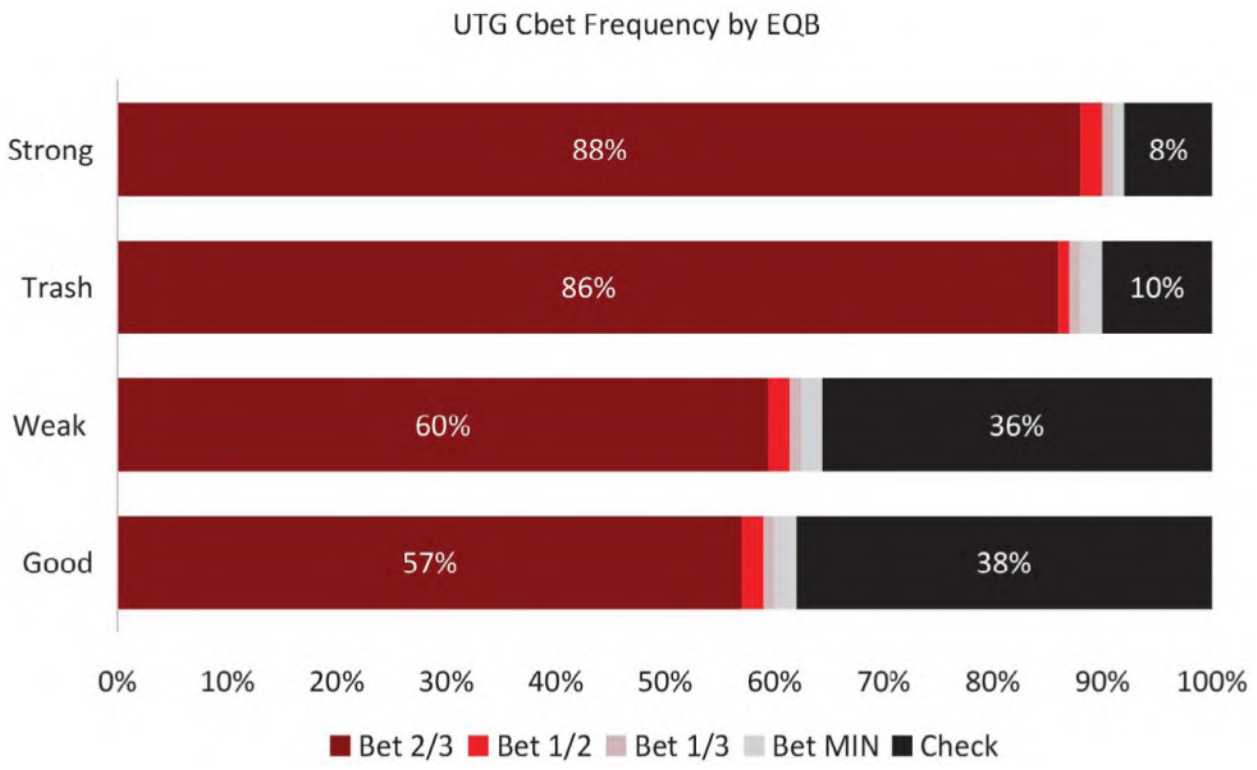


Diagram 62

On this flop texture, IP has 59% equity and is able to capture 69.04% of the pot. Simplifying the strategy to a single 2/3-pot bet-size retains most of IP's EV, 68.95%, for an EV loss of -0.09 or -0.6bb/100.

A 100% c-bet strategy cannot be implemented on this flop as it would cost UTG an EV loss of 4.25% of the pot, or -24bb/100. At equilibrium, the BB's x/r frequency vs UTG is about 4%, but vs the 100% c-bet strategy, the BB can attack UTG by increasing the x/r frequency to a gigantic 48.42%.

Hand	% of Range	Equity	EV	EQR	Bet 2/3	Bet 1/2	Bet 1/3	Bet Min	Check
Sets	3.1%	90%	209%	231%	66.5%	2.7%	2.0%	3.7%	25.2%
Over Pair	15.4%	78%	123%	158%	92.3%	1.9%	0.7%	0.9%	4.2%
Top Pair	7.3%	73%	96%	133%	70.7%	1.9%	1.1%	1.6%	24.6%
Second Pair	3.3%	65%	72%	110%	39.7%	1.9%	1.4%	2.6%	54.5%
Pocket 2-3 (77-55)	6.3%	55%	42%	75%	25.8%	1.3%	1.3%	3.1%	68.5%
Third Pair	1.0%	52%	40%	76%	69.8%	2.0%	1.0%	1.2%	26.0%
Combo Draw	1.7%	65%	132%	203%	68.6%	1.9%	1.2%	2.2%	26.2%
Flush Draw	6.2%	65%	112%	172%	75.1%	1.89%	1.0%	1.6%	20.4%
OESD	1.7%	50%	83%	168%	59.1%	2.1%	1.2%	2.3%	35.3%
Gutshot	3.4%	42%	39%	129%	70.1%	1.6%	0.9%	1.5%	25.9%
Ace-high	36.7%	46%	24%	83%	51.3%	1.5%	1.0%	2.1%	44.1%
King-high	14.2%	40%	28%	70%	80.1%	1.8%	0.9%	1.3%	15.9%
Full Range	100%	56%	63%	112%	64.3%	1.7%	1.0%	1.8%	31.1%

Table 115: UTG C-betting Range Breakdown on 9♥8♥4♦

The UTG strategy breaks down as follows:

Strong hands

Strong hands are bet most of the time. Hands such as AA, top set and middle set get checked back ~8%.

Good hands

Good hands are played passively, with made hands such as middle pairs mostly being checked. Good draws such as combo draws and flush draws are mostly c-bet, while weaker draws such as OESD mostly get checked. Top pair wants to check back 24% of the time and can be c-bet in a reverse linear fashion, with the strongest kicker A9 being c-bet 100% and T9s being c-bet 66%.

Weak hands

The only weak hands in IP's range that don't have any sort of draw are K-high and A-high. In general, combos with a BDFD get c-bet more often than combos without a BDFD.

Trash hands

The only hand with less than 33% equity in IP's range is 65s, and it gets c-bet ~95% of the time.

Facing a MIN x/r

On this flop, the BB should only x/r about 4% of the time, given a lack of strong hands in their range. The flop x/r range includes hands such as two pair, overpairs, combo draws and some overcards with a BDFD.

UTG's response at equilibrium is to fold about 32% of the time, including mostly overcards without a BDFD. UTG 3-bets all-in ~13.5%, and 3-bets a smaller size about 8% of the time. The 3-betting range includes hands such as overpairs, top pair top kicker and the nut flush draw (particularly with two overcards) and some bluffs with hands such as A♥ plus an overcard. The rest of the range calls, for a calling frequency of ~47%.

Flop Strategy Example 4

Mid c-bet % and small bet-size: BB vs BN on J♠6♥6♦ (40bbs)

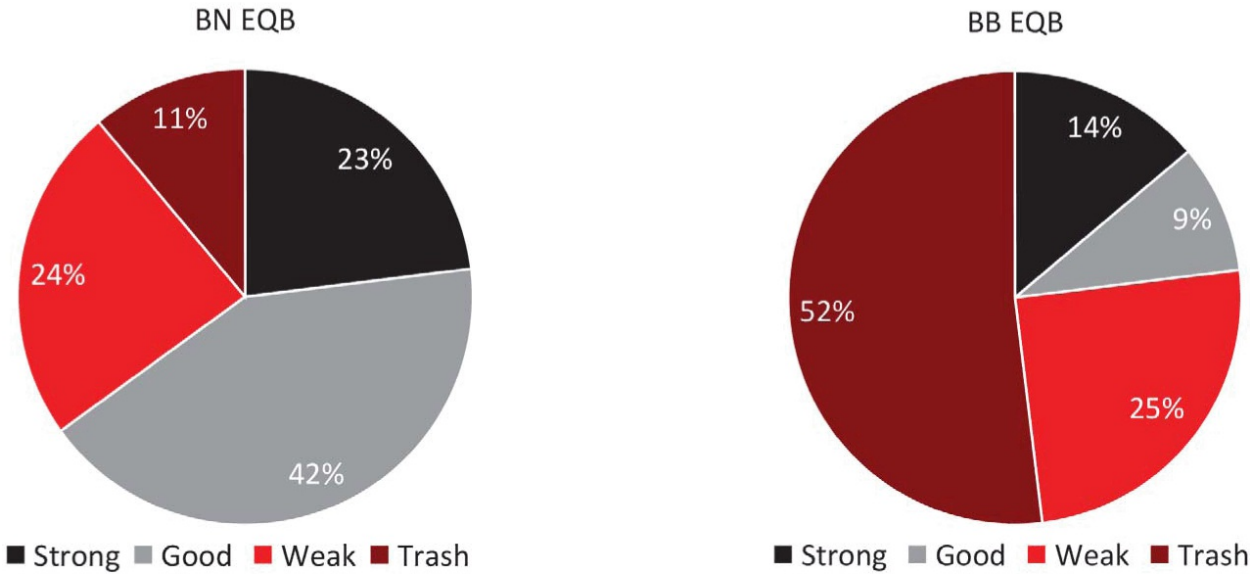


Diagram 63: Mid C-bet % and Small Bet-size: BB vs BN on J♠6♥6♦ (40bbs)

On this flop, the BB's range is very polar and has a healthy number of strong hands at 14%, not too far away from the BN's 23%. More specifically, the BB's range has 8.9% trip sixes, while the BN only has 5%. For this reason, the BN cannot use a large sizing, but the BB still has 52% trash hands that will struggle to continue against even a min-bet. This allows the BN to have a high overall c-bet frequency of 72%.

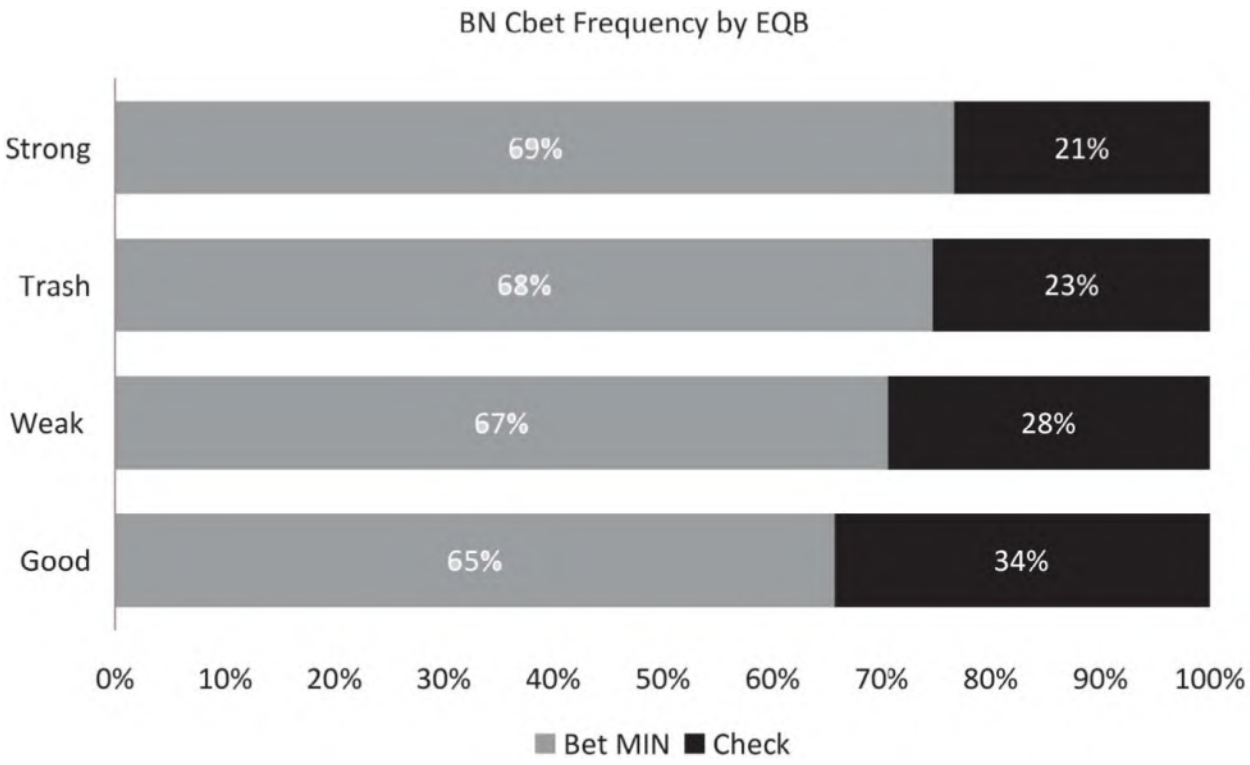


Diagram 64

Hand	% of Range	Equity	EV	EQR	C-bet MIN	Check
Quads	0.2%	100%	243%	243%	15%	85%
Full House	0.7%	99%	261%	263%	39%	61%
Trips	5.0%	94%	202%	214%	99%	1%
Over Pair	3.0%	85%	129%	152%	76%	24%
Top Pair	14.0%	80%	96%	121%	76%	24%
Pocket Pair 1-2 (TT-77)	4.0%	69%	71%	102%	47%	53%
Under Pair	4.0%	52%	48%	93%	50%	50%
A-high	26.4%	59%	45%	75%	72%	28%
K-high	16.5%	51%	37%	74%	68%	32%
Air	26.3%	36%	33%	93%	74%	26%
Full Range	100%	57%	61%	106%	72%	28%

Table 116: BN C-betting Range Breakdown on J♠6♥6♦

The BN strategy breaks down as follows:

Strong hands

Some strong hands such as quads (66) and full houses (JJ) block the BB's continuing range, so they benefit from trapping and checking back the flop with some frequency. This gives the Villain the chance to either start bluffing or catch some equity. Also, IP's range is protected when they check back the flop. Overpairs QQ+ like checking back the flop with some frequency when they block the BB's BDFDs that would continue on the flop. So, a hand like K♣K♦ is more likely to c-bet than a hand like K♠K♥.

Good hands

Good hands are pocket pairs TT-22 (except 66) and these are c-bet half the time.

Weak hands

Suited A-high gets c-bet linearly, with the strongest AK-AQs being c-bet 100%, then the middling ones ATs-A7s being c-bet 80% and the baby A-high A5s-A2s being c-bet only 34%. The logic is that the stronger A-highs have better equity vs the BB's x/r range, so IP wants to have them more often when facing a x/r. Also, they have better blockers to top pair, and get called by worse A-high more often.

Trash hands

Air gets c-bet 75% of the time.

Facing a 50% Pot x/r

The total BB x/r frequency on this board is about 27%, with a polarized range including some strong hands such as trips, a few good top pairs and some very weak hands such as BDFD and BDSTD combos.

The BN's equilibrium response to the x/r has them folding about 35% of hands, 3-betting 11% using a min-raise and calling 54%. The BN's folding range includes all air, and many weak A- and K-high with only one overcard to the flopped J. The BN's 3-betting range is extremely polarized, including hands such as A6 and K6, some strong top pair, and some bluffs with two overcards with a BDFD or BDFD and BDSTD. The calling range contains any pair+, most A- and K- and Q-high and hands with backdoor equity.

Flop Strategy Example 5

Low c-bet % and big bet-size: BB vs BN on 8♥6♦2♠ (40bbs)

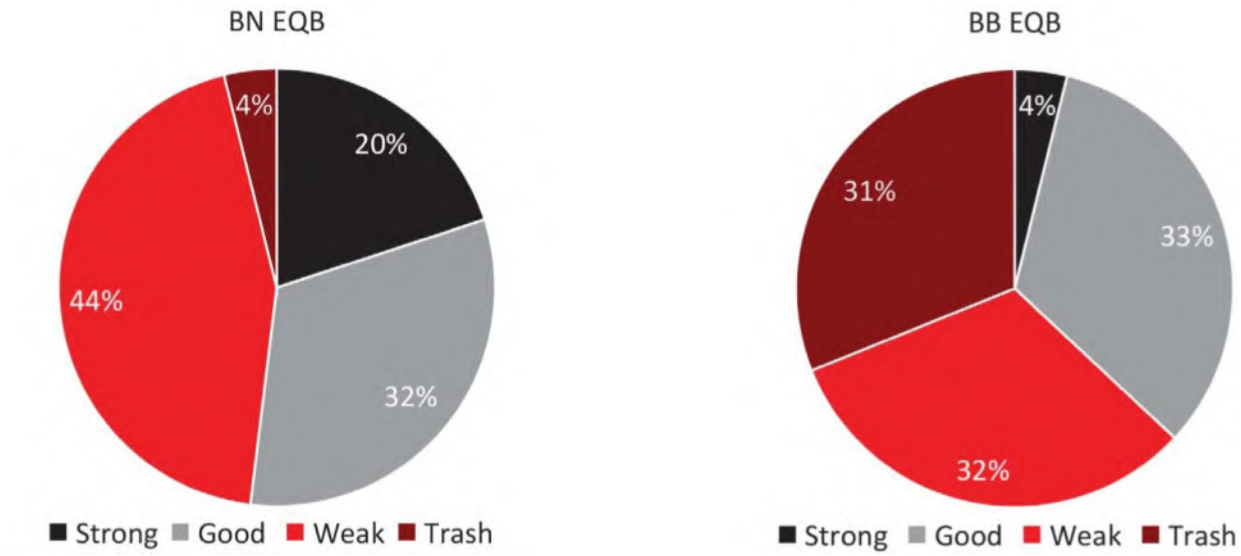


Diagram 65: Low c-bet % and Big Bet-size: BB vs BN on 8♥6♦2♠ (40bbs)

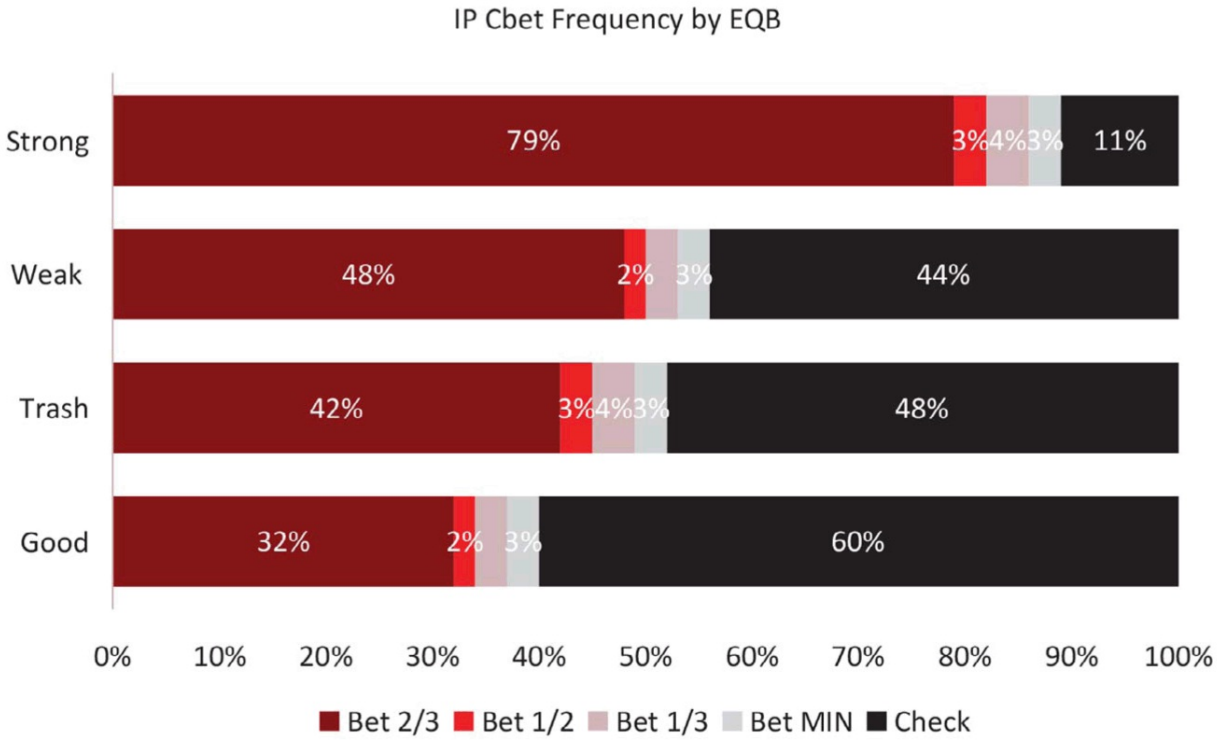


Diagram 66

On 862r, the BB has few strong hands compared to the BN. This incentivizes the BN to use a big bet-size. However, the BN also has many good and weak hands that benefit from playing a small pot and taking a free turn card. These range distributions results in a more polarized big bet-size with a low c-bet frequency.

Hand	% of Range	Equity	EV	EQR	Bet 2/3	Bet 1/2	Bet 1/3	Bet Min	Check
Sets	1.5%	93%	243%	260%	45.4%	6.2%	10.5%	41.9%	23.0%
Two Pair	0.3%	88%	185%	211%	86.5%	6.1%	5.9%	1.3%	0.2%
Over Pair	6.2%	92%	158%	195%	94.8%	2.3%	1.9%	0.9%	0.1%
Top Pair	12.7%	76%	118%	155%	74.9%	3.4%	3.4%	2.1%	16.3%
Pocket 1-2 (77)	1.0%	69%	81%	117%	38.5%	2.3%	2.9%	2.8%	53.5%
Second Pair	7.3%	68%	79%	117%	36.7%	2.2%	3.0%	3.2%	54.9%
Pocket 2-3 (55-33)	2.9%	55%	45%	82%	4.0%	1.2%	0.9%	1.7%	92.2%
Third Pair	3.1%	56%	55%	97%	34.5%	1.6%	2.5%	2.4%	59.0%
OESD	1.9%	46%	94%	206%	5.2%	1.4%	4.3%	5.4%	93.7%
Gutshot	4.3%	40%	67%	169%	47.0%	2.5%	3.1%	3.1%	44.4%
Ace-high	23.4%	52%	35%	67%	34.4%	2.2%	3.6%	4.1%	54.8%
King-high	15.6%	47%	33%	70%	41.9%	2.3%	3.0%	2.8%	50.1%
Air	20.2%	36%	33%	92%	56.7%	2.6%	2.8%	2.3%	35.6%
Full Range	100%	55%	63%	115%	48.6%	2.5%	3.1%	3.0%	42.8%

Table 117: BN C-betting Range Breakdown on 8♥6♦2♠

The IP player strategy breaks down as follows:

Strong hands

It is important for IP to have some strong hands that can continue on brick runouts. For this reason, some strong hands such as top set and top pair weak kicker get checked back with some frequency. In fact, top set wants to check back or bet small. Since I advocate one bet-size by flop, I think a good strategy would be to simply always check back top set in this spot. A trend that typically loses a lot of EV to IP that I see all the time is to c-bet all strong and good hands on the flop and checking back an unbalanced and capped range that can be attacked by the BB on future streets.

Good hands

Good hands really want to check back a lot and realize equity instead of being raised off the pot. Middle and low pocket pairs mostly want to check back the flop, except 77, which can be bet half the time, as it can get value from middle pair. The strongest middle pairs such as A6 and K6

are mostly c-bet and the weaker ones are typically checked back. Bottom pair top kicker is mostly c-bet, and the rest are checked back. Ace-highs without a BDFD are c-bet reverse linearly (A6o is c-bet more often than AQo) except AKo, which is mostly bet and the ones with a BDFD are c-bet linearly (AKs is c-bet more often than A3s).

Weak hands

Weak hands are c-bet reverse linearly when they cannot call a flop x/r. For example, K6o gets c-bet more often than K9o, which also gets c-bet more often than KQo. So, the strongest Kx that will do well on many turns can be checked back, while the weaker ones better serve as bet/folds. OESDs are mostly checked back, while gutshots and Q-high with two overcards are mostly c-bet.

Trash hands

Weak Q-high, J-high and T-high with no draws are c-bet more often than not, but you have to give up and check back some of them because c-betting all your trash would make your c-betting range too weak.

Facing a 50% Pot x/r

On 862r, the BB's range does not have many strong hands, thus the equilibrium flop x/r frequency is low, at ~8%. The x/r range mostly includes hands such as top pair good kicker, some OESD, some weak hands like gutshot plus BDFD and some random overcards.

The BN's equilibrium response is to fold 43% of the time, call 34% and 3-bet all-in 23%. The BN's 3-betting range includes hands such as QQ-99, top pair good kicker+, and some random two overcards with a BDFD such as KTs, Q9s, J9s and T9s. The calling range is pretty much any pair, any gutshot or better draw and most overcards with a BDFD. Air and overcards with no BDFD are always folded.

Flop Strategy Example 6

Low c-bet % and small bet-size: BB vs BN on 5♥5♦4♥ (40bbs)

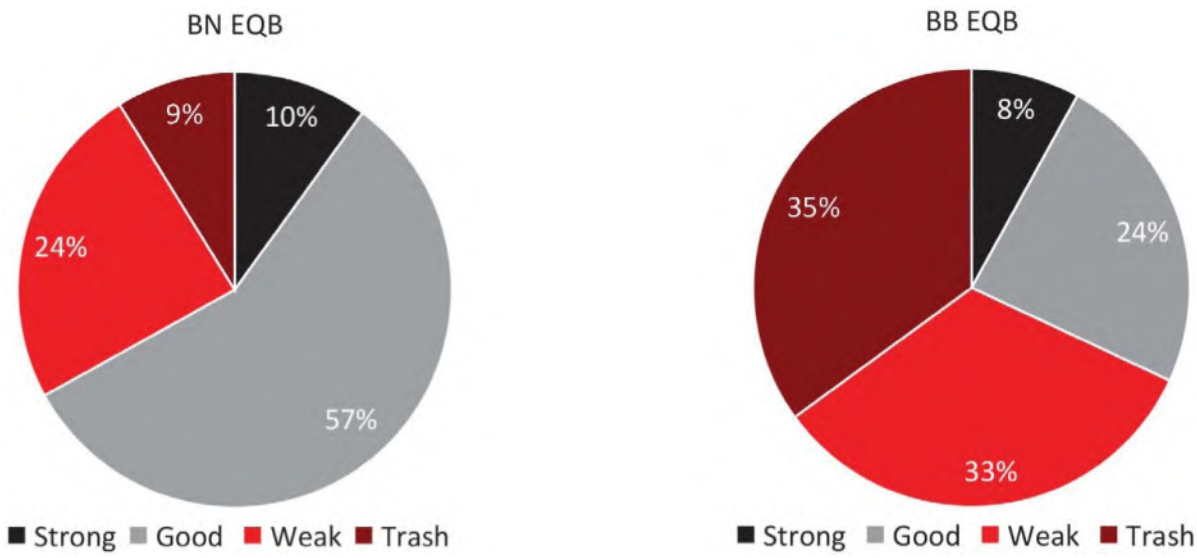


Diagram 67: Low c-bet % and Small Bet-size: BB vs BN on 5♥5♦4♥ (40bbs)

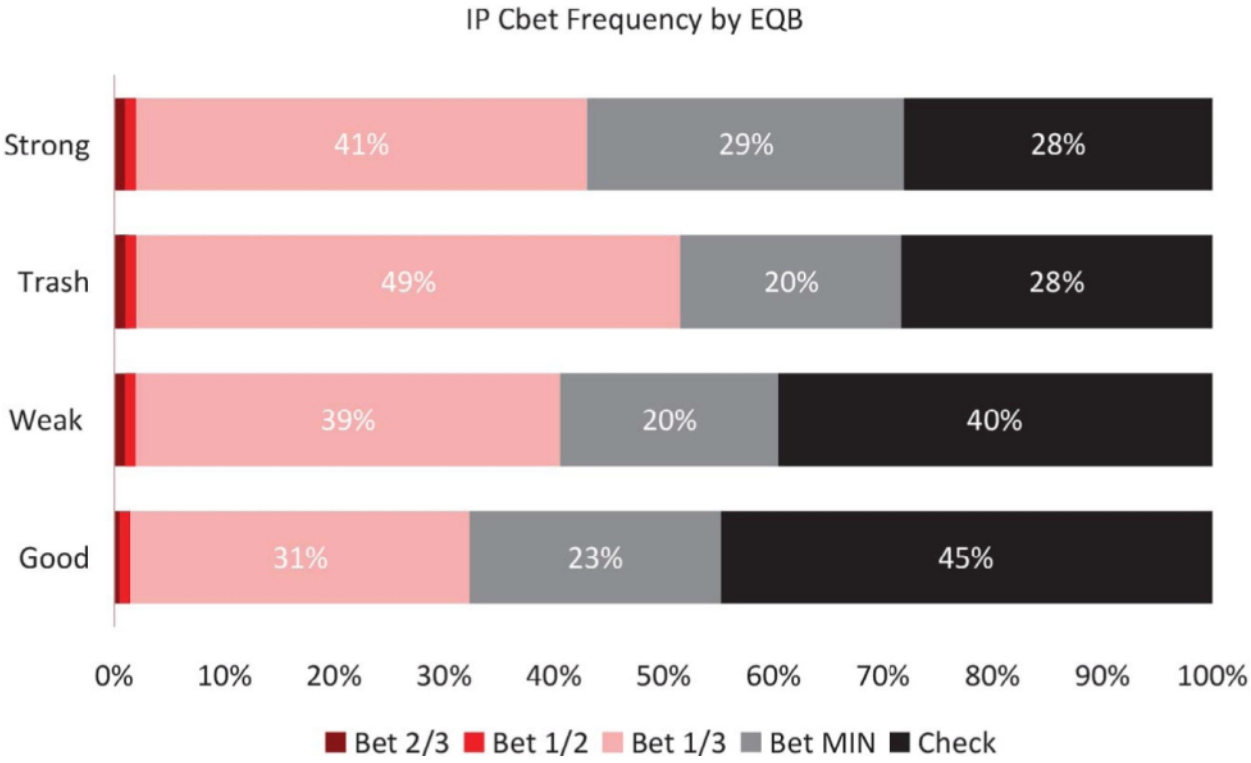


Diagram 68

On this flop, the BN doesn't have a significant range advantage, hence the preference for the smaller bet-sizes. In fact, most of the BN range is made of good hands, giving a depolarized distribution that will result in a low c-bet frequency, as many good and weak hands in the BN's range will benefit from checking back the flop.

Hand	% of Range	Equity	EV	EQR	C-bet 2/3	C-bet 1/2	C-bet 1/3	C-bet Min	Check
Quads	0.2%	99.9%	268%	268%	0.0%	0.3%	0.7%	12.4%	86.7%
Full House	0.8%	97%	257%	265%	0.0%	0.4%	37.9%	39.6%	22.1%
Trips	4.3%	91%	195%	214%	0.9%	1.5%	64.6%	31.0%	2.0%
Over Pair	8.6%	77%	107%	140%	1.0%	1.2%	43.2%	24.2%	30.4%
Second Pair	4.4%	65%	67%	102%	1.0%	0.9%	42.2%	18.7%	34.2%
Under Pair	1.9%	52%	54%	103%	0.3%	0.4%	33.1%	20.3%	45.8%
Combo Draw	0.8%	66%	116%	177%	0.4%	0.9%	30.4%	23.7%	44.6%
Flush Draw	6.1%	64%	96%	150%	0.6%	0.9%	39.8%	24.7%	34.0%
OESD	0.5%	44%	79%	178%	0.1%	0.6%	44.8%	26.9%	27.6%
Gutshot	5.7%	58%	57%	98%	0.4%	0.5%	25.2%	21.3%	52.7%
A-high	19.1%	62%	49%	80%	0.3%	0.5%	29.7%	24.1%	45.3%
K-high	17.7%	53%	36%	69%	0.3%	0.4%	18.3%	23.3%	57.7%
Air	30%	37%	29%	79%	0.7%	1.0%	42.2%	20.2%	35.9%
Full Range	100%	55%	59%	107%	0.5%	0.8%	35.3%	22.8%	40.6%

Table 118: UTG C-betting Range Breakdown on 5♥5♦4♥

The IP player strategy breaks down as follows:

Strong hands

Strong hands are slowplayed ~28% of the time. Quads are mostly checked back, full houses are checked back about 22% of the time, trips are almost always c-bet and overpairs get c-bet in a reverse linear fashion. TT gets c-bet 76%, JJ 64%, QQ 50%, KK 40% and AA 22%, as the bigger pairs need less protection and make great hands to call down on many runouts after checking back the flop. A-high combo draws get c-bet ~55%.

Good hands

Good hands are c-bet ~59% of the time. Mid pairs 66-99 are c-bet almost 100%, OESD gets mostly c-bet, gutshots mostly like to check back and A-high flush draws are c-bet linearly, with the strongest kickers being c-bet more often than the ones with weak kicker. K-high and Q-high flush draws gets c-bet reverse linearly, with the highest kickers being checked back more often and weaker flush draws being c-bet ~ 2/3 of the time.

Weak hands and trash hands

Air gets c-bet about 64% of the time, getting mostly bet/folded vs a flop x/r and only continuing when having a diamond BDFD and a small frequency when having a heart.

Facing a 25% Pot x/r

On 5♥5♦4♥, the BB isn't as polarized as it was on J66r because, on 5♥5♦4♥, many of the BB's hands that would be trash on J66 now have a flush draw, OESD or some sort of gutshot. This makes the BN c-bet the flop less frequently on 5♥5♦4♥. The BB should x/r the flop vs a 1/3-pot c-bet with a range that has a good mixture of strong hands such as full houses, trips, flush draws, SD, gutshots, and backdoor equity combos.

The BN's GTO strategy vs a flop x/r has them 3-betting the flop 19% of the time using a 25%-pot raise, calling 56% and folding 25%.The BN's 3-betting range includes hands such as 38% of trips (mostly with a high kicker), 34% overpairs (mostly JJ-66), 26% of flush draws (mostly A-high flush draws with two overcards) and some A♥ and K♥ bluffs. The folding range is mostly air and overcards with no draws or backdoor BDFD. The calling range is made of any pair+ and draws that are raised and overcards with BDFD.

Note About Mixing and Balancing

It is important to understand that all of the mixing that happens with all hand types across all the range examples does not have to be memorized. It simply serves the purpose of illustrating how the solver divides up the ranges. In-game against human opponents, the options with any given hand tend to be more binary and one action will yield a higher expectation than any other action. Mixing can be used as a defensive measure against good players but, even then, getting the exact right frequencies often times is neither possible nor necessary.

Developing OOP C-betting Strategies

OOP c-betting is fundamentally different from IP c-betting. When you are the player in position, the Villain will generally be playing from the blinds with a wide range of about 50%-70% hands. When the Villain cold calls (and is thus IP), their range will be much tighter, typically 4%-20% hands. This significant difference in the Villain's pre-flop range produces a more symmetric post-flop equity distribution that results in a reduced overall betting frequency. The closer the ranges are, the less incentivized you should be to start betting the flop.

Now that you are OOP, there is another issue you don't have when you are IP. Checking the

flop does not immediately allow you to see the turn and realize equity because, when you check the flop from OOP, the IP player has the option to bet and force some of your hands to fold. For this reason, you have to check a stronger range when OOP than when IP, as your range can be immediately attacked by the Villain. This forces you to check a range that not only will be balanced on the average turn card when the action goes x/x, but also a range that is balanced immediately and can withstand aggression.

Stack depth has a significant effect on pre-flop strategies and thus the cold call ranges will be substantially different from one stack depth to the other, resulting in different post-flop equity distributions. In this section, we will focus on BN cold calls because the BN is the position from outside the blinds that typically cold calls the most. As for the opener, we will focus on CO and UTG opens, to provide the two most extreme examples of this set-up, one against the widest possible opening range, and once against the tightest. The play from all other positions will fall within these two extremes.

The stack depths we will study are 40bb and 20bb, typical for a MTT setup with 12.5% antes, and the following betting structure:

♦ OOP can bet (20bb): all-in, 2/3-pot, 1/2-pot, 1/3-pot, min-bet

♦ OOP can bet (40bb): 3/4-pot, 2/3-pot, 1/2-pot, 1/3-pot, min-bet

Hero Position	Stack Depth	Hero Range	BN Range	Hero EQ	Hero EV	Hero EQR
UTG	40	15.8%	15.9%	55.4%	54.4%	98.0%
UTG	20	15.9%	12.2%	53.8%	51.3%	95.0%
CO	40	36.4%	19.6%	50.1%	46.2%	92.0%
CO	20	31.8%	8.4%	49.0%	42.8%	87.0%

Table 119: Hero vs BN Overall Stats

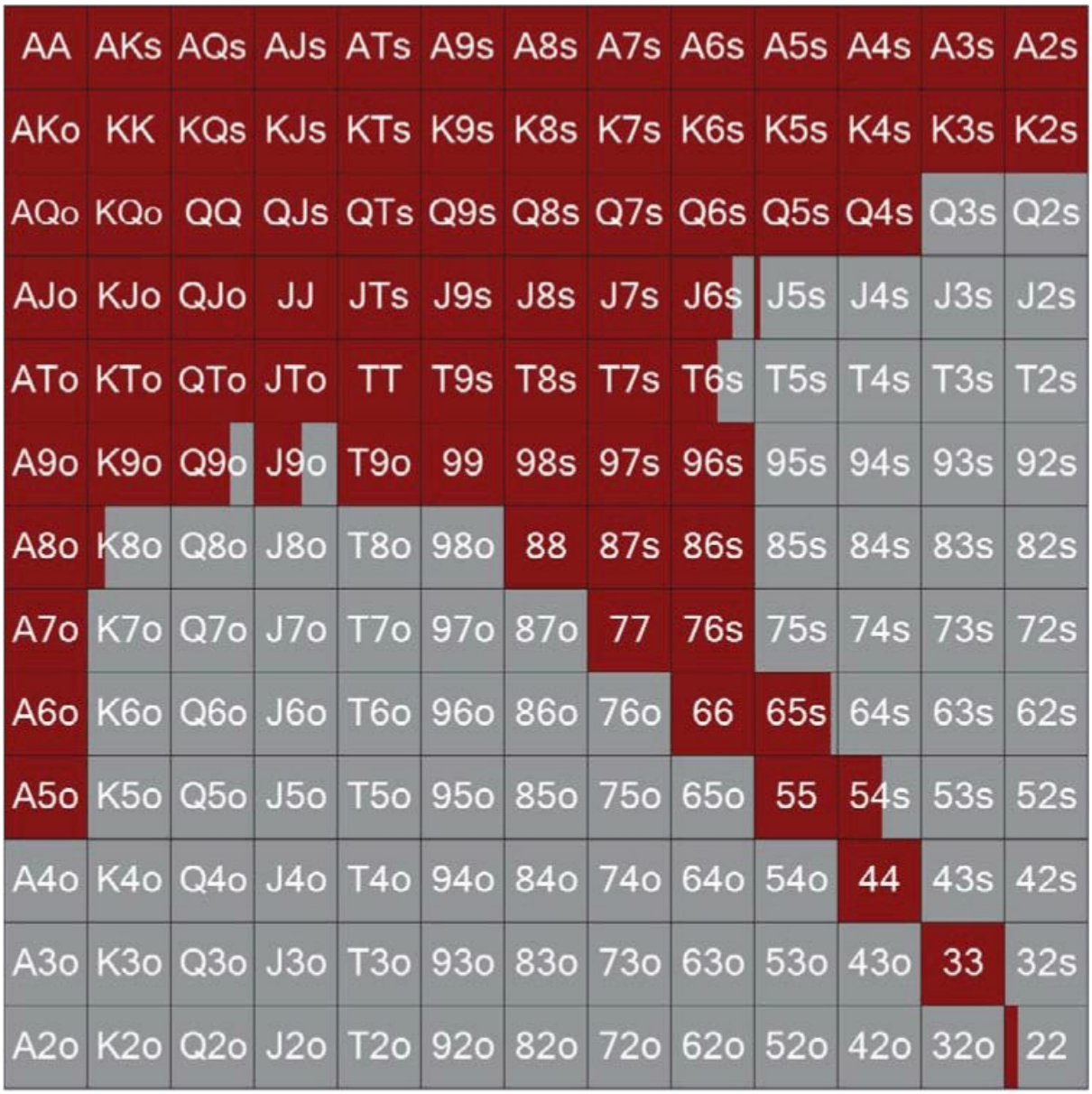
The best situation for Hero is when is playing UTG with 40bb. In this set-up, both players have almost the same number of hands in their ranges but Hero's range dominates the BN in all other set-ups. The BN's range is tighter than Hero's, creating a more equal situation that will ultimately benefit the BN, given that they are playing IP post-flop.

Of course, for the BN to achieve this favorable post-flop situation, they had to take a risk when calling the open raise in the first place. So it is not as if the BN could simply cold call any hand, as they would risk being pushed off by the blinds and also risk playing multi-way post-

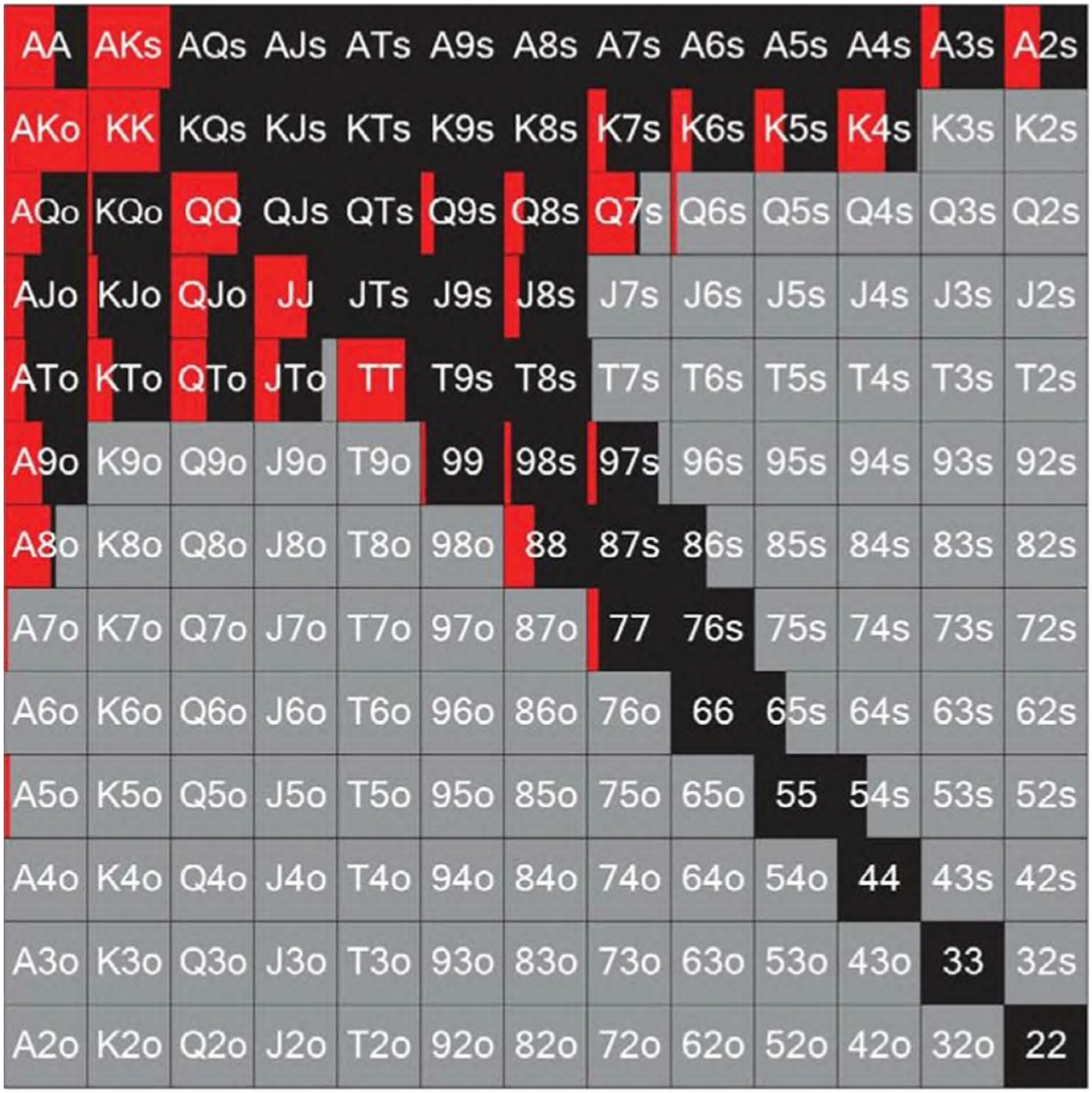
flop, which will reduce their share of the pot.

Ranges in Play

The following hand ranges identify the ranges in play for the subsequent analysis *(Hand Ranges 341-348)*



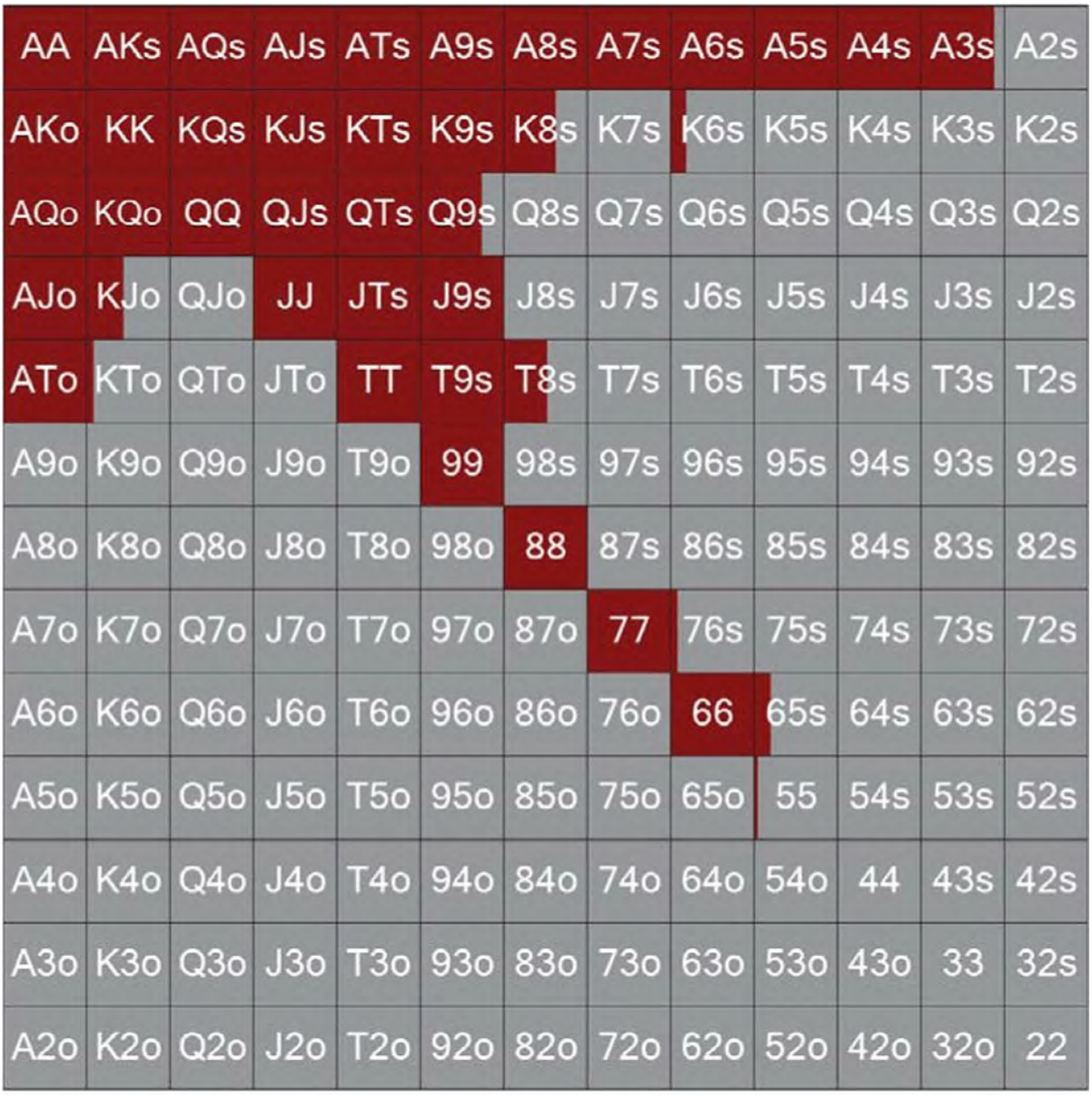
Hand Range 341: CO RFI 40bb
• Open 2.3x 36.4% / • Fold 63.6%



Hand Range 342: BN vs CO 40bb

• 3-bet 7.5% / • Call 19.6% /

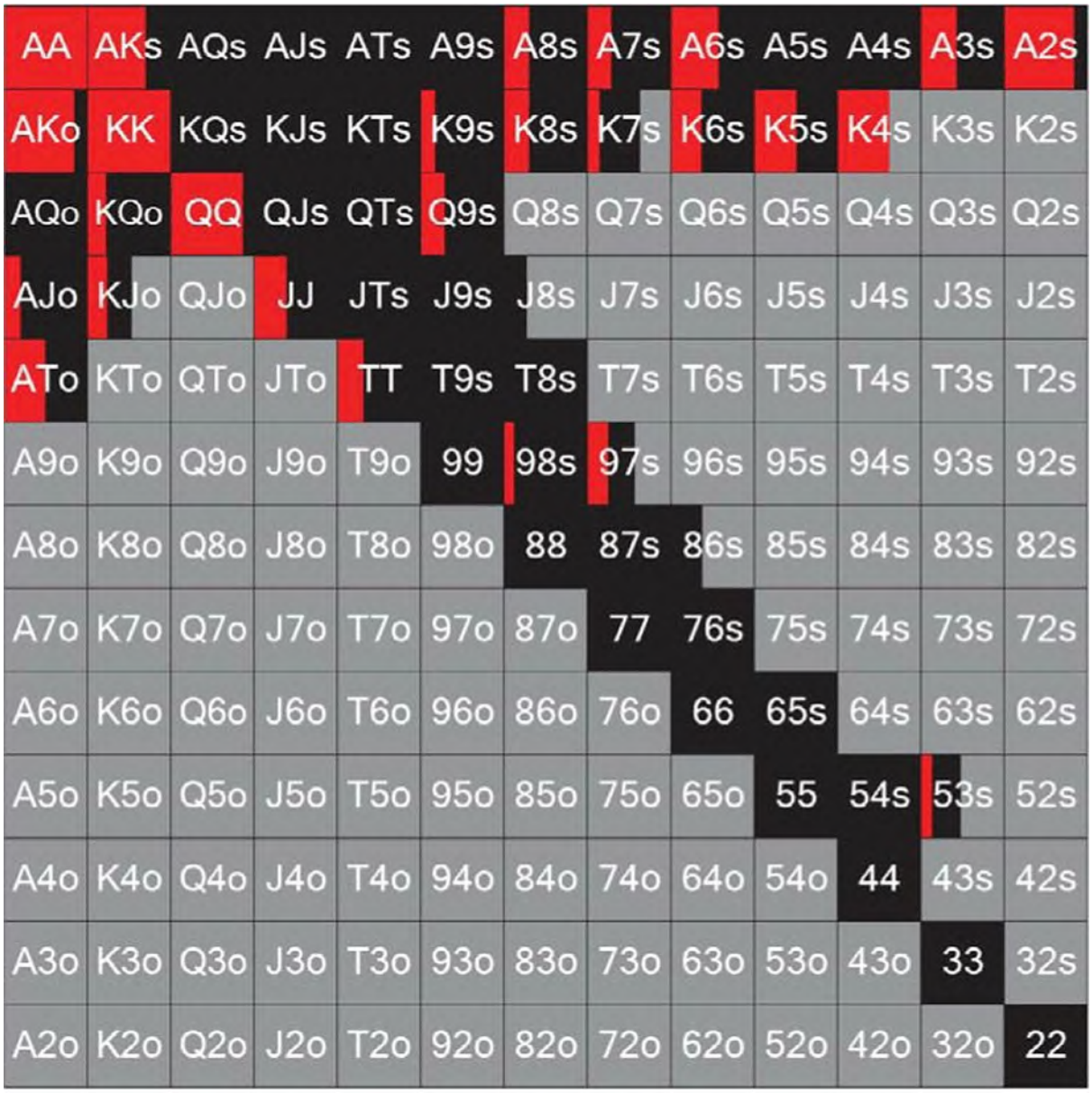
• Fold 72.9%



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

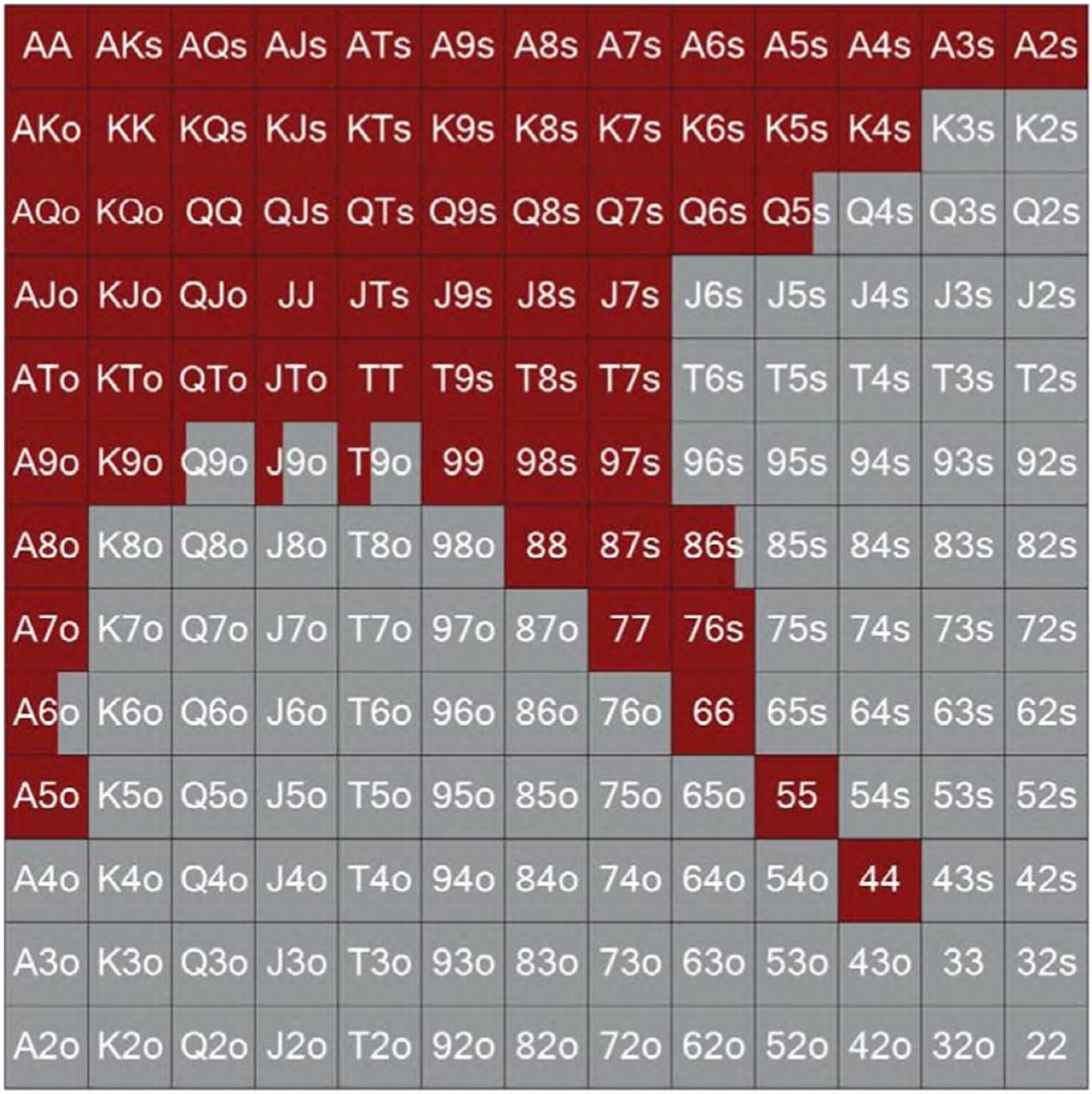
Hand Range 343: UTG RFI 40bb

• Open 2.3x 15.8% / • Fold 84.2%



Hand Range 344: BN vs UTG 40bb

• 3-bet 5.2% / • Call 15.9% / • Fold 78.9%



Hand Range 345: CO RFI 20bb

• Open 2x 31.8% / • Fold 68.2%

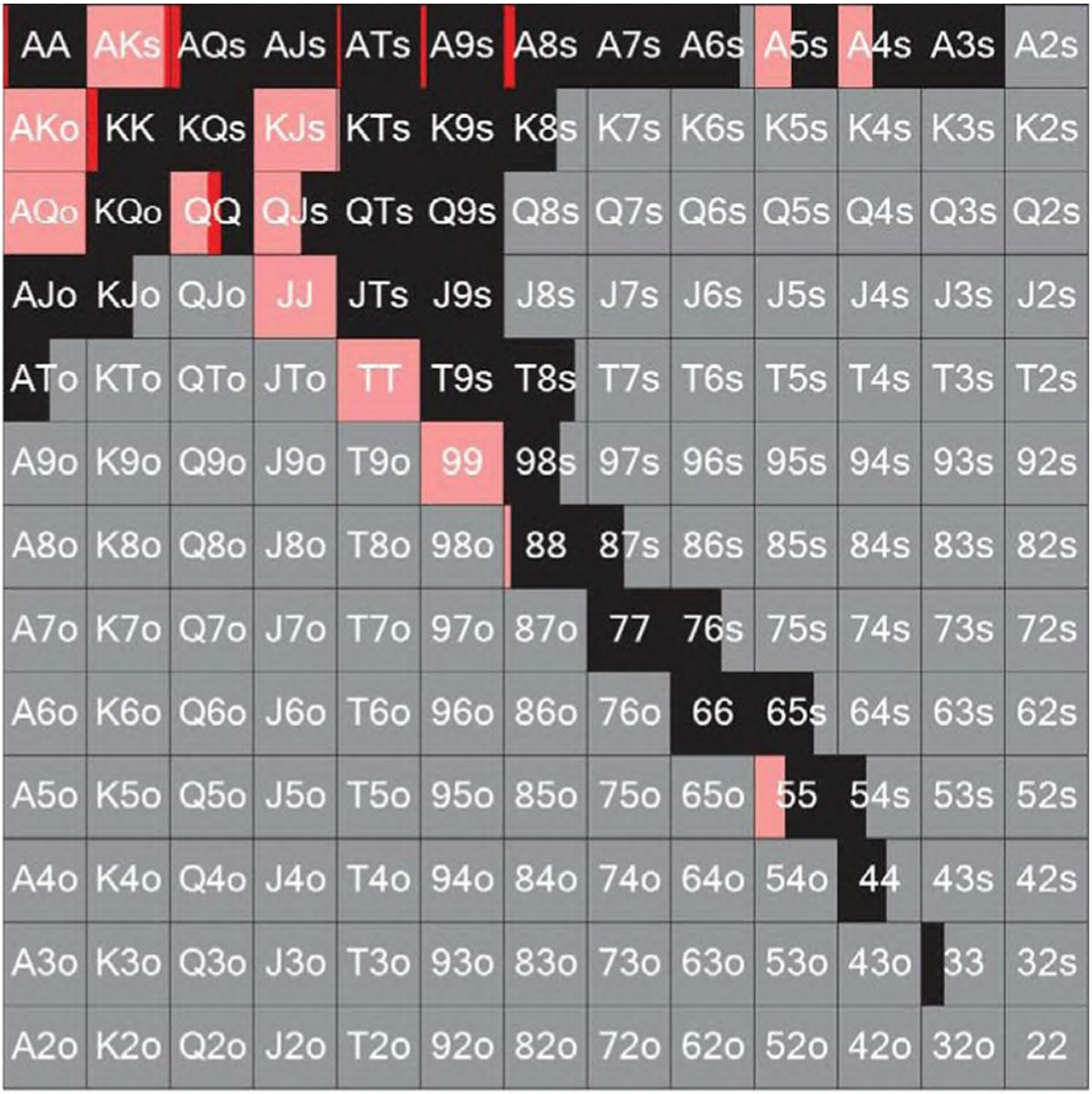
Hand Range 346: BN vs CO 20bb

• All-in 12.3% / • Call 8.4% / • Fold 79.2%

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

Hand Range 347: UTG RFI 20bb

• Open 2x 15.9% / • Fold 84.1%



Hand Range 348: BN vs UTG 20bb

• All-in 4.6% / • 3-bet 0.3% /

• Call 12.2% / • Fold 82.9%

Overall, the strategies could be simplified to two bet-sizes, a big bet-size and a small bet-size, depending on the flop. With 40bb, you can use 3/4-pot and min-bet or 1/3-pot, and with 20bb 2/3-pot and min-bet or 1/3-pot. I did not test 1/4-pot bet-size, but I think it would probably work well and could potentially replace the min-bet and 1/3-pot. With deeper stacks, overbets should be introduced to the play.

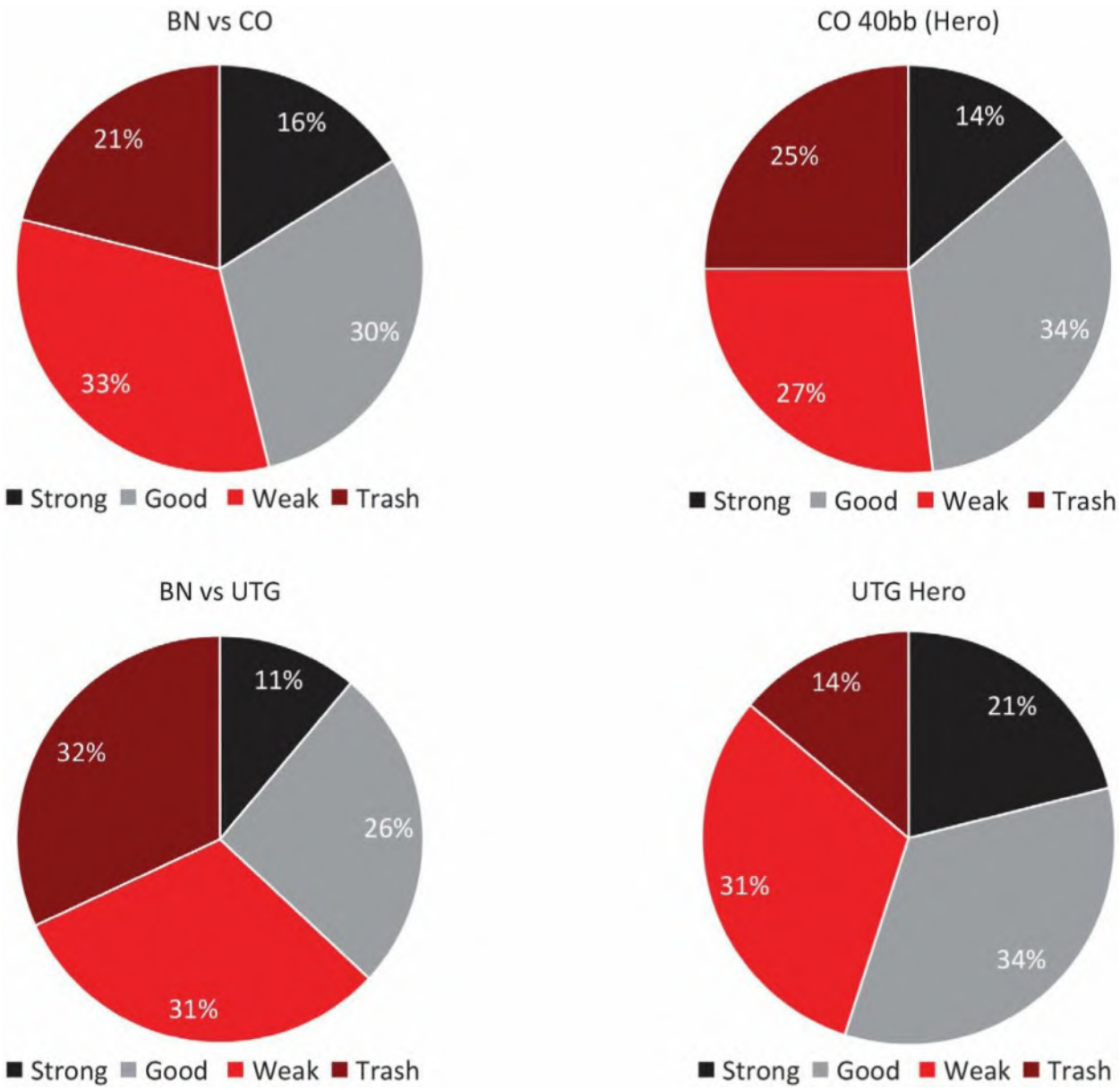


Diagram 69: 40bb 3-bet Pot Equity Buckets

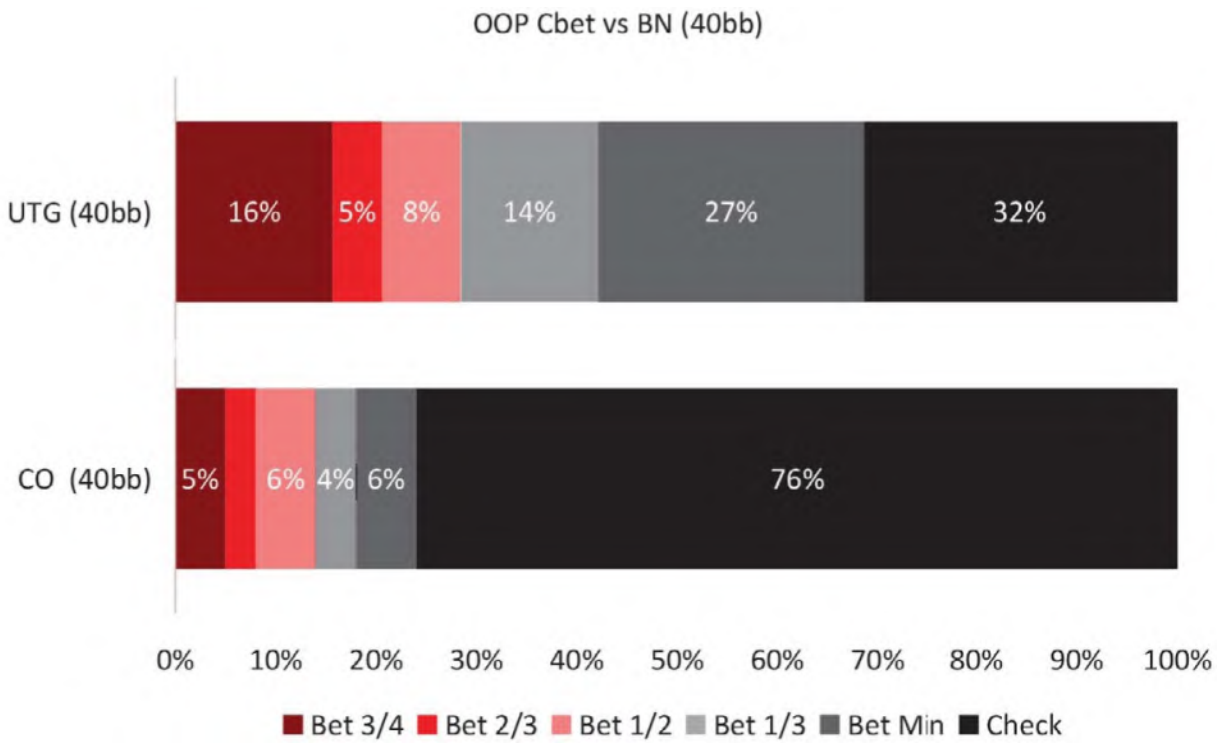


Diagram 70

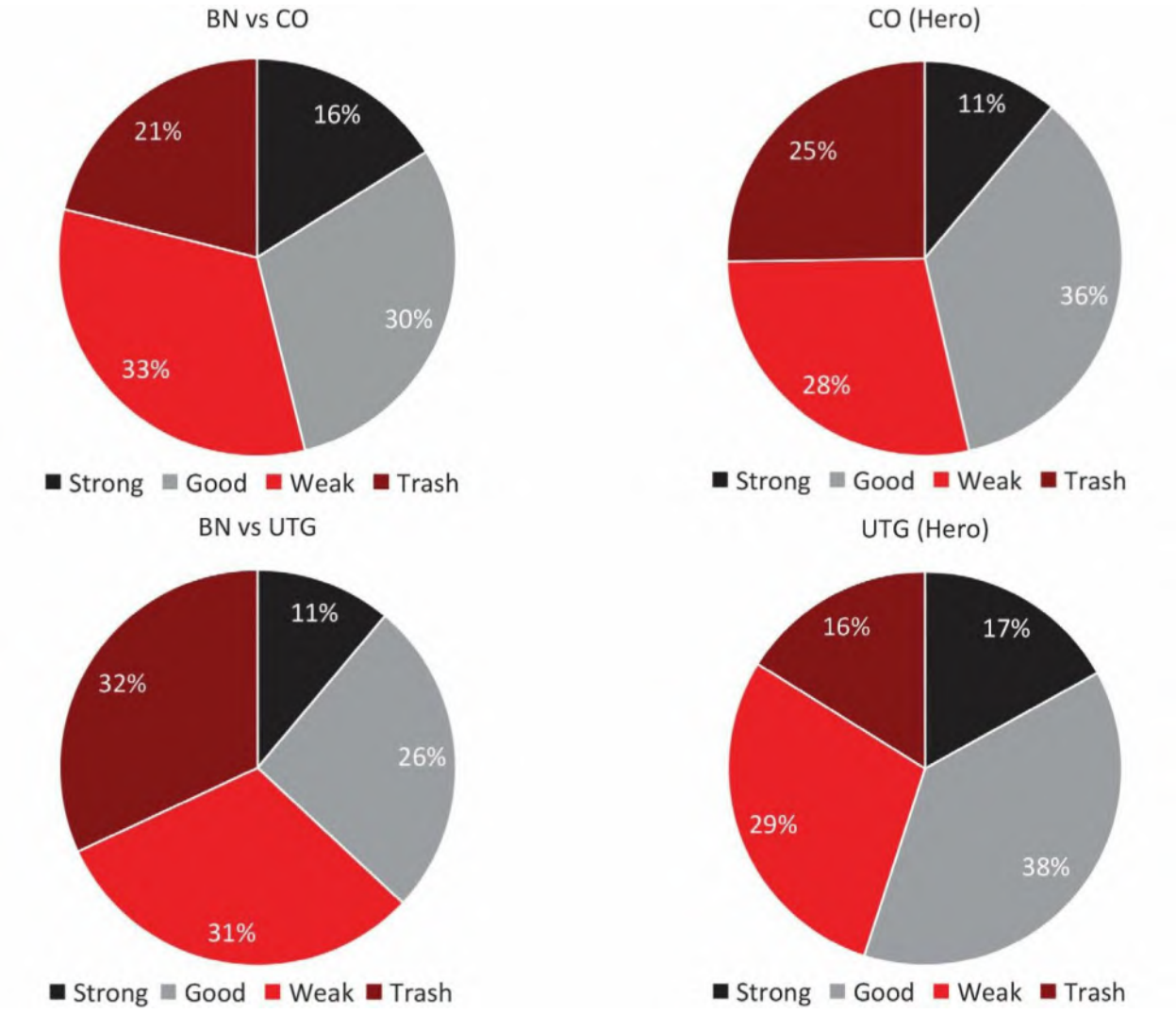


Diagram 71: 20bb 3-bet Pot Equity Buckets

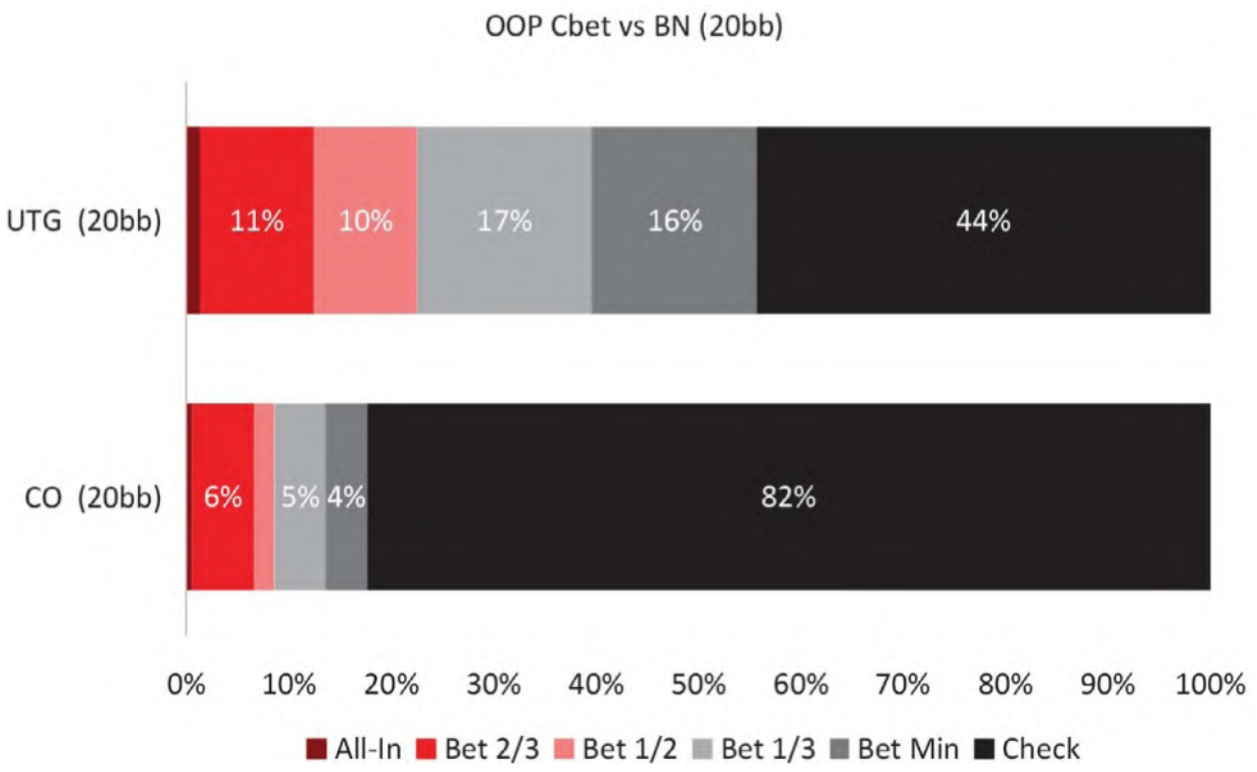


Diagram 72

UTG c-bets a lot more frequently than the CO. In fact, the CO's range is in general weaker than the BN's and CO could easily opt for a 100% checking strategy with minimal to no EV loss. This is similar to the BB vs IP situation where the BB can opt to never donk bet the flop. This strategy works well as an exploit against the population because most players tend to automatically bet the flop when OOP checks to them, whereas the equilibrium strategy is to take a stab at the pot half the time. Checking the flop with all hands allows Hero to play an aggressive check/raising strategy, taking advantage of IP's aggression, while reducing the effective SPR and positional disadvantage.

Many players make the mistake of c-betting way too often when OOP, particularly with weak and trash hands, only to x/f the turn most of the time. This is a serious leak that can be easily attacked by observant opponents who can call the flop bet and then fire the turn 100% of the time when checked to.

C-betting Range Strategy Overview: UTG vs BN 40bbs

Much as with IP c-bets, OOP c-betting will heavily depend on the board. In this section, we will examine UTG vs BN 40bb deep c-betting to get an overall picture of how the strategies change when compared to playing IP.

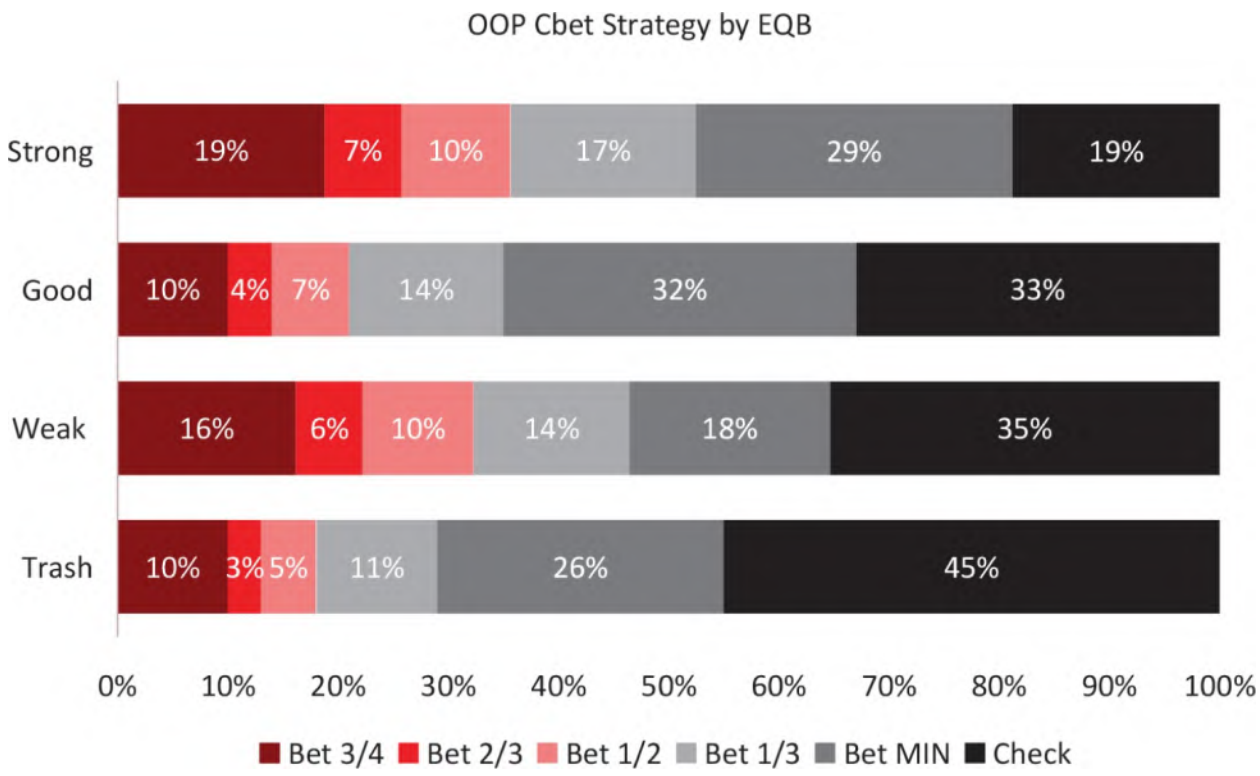


Diagram 73

Even when OOP, UTG's range is still strong enough to c-bet most of the time, checking the flop 32% on average. Strong hands are checked 19% of the time, which is more than 3x as often as when Hero is IP. Checking the flop does not immediately lead to a turn card, so Hero still has to worry about IP betting after the flop check. For this reason, Hero needs to have, on average, a stronger and more balanced checking range, allowing Hero to x/r the flop at a reasonable frequency, thus offering protection him from IP betting too often with a large sizing when checked to.

When Hero is IP, the trash hands are generally c-bet more often than good and weak hands, making this c-bet range more polarized. However, when Hero is OOP, this role reverses and good and weak hands are c-bet more often than trash hands. The reason for this is that Hero still has to act first on the turn, which will give away information about their hand strength. If they bet too many low equity hands when OOP, their average turn range will be too weak and consequently exploitable. For this reason, instead of putting in many chips with a lot of trash hands only to later give up the pot, Hero simply checks them with the intention folding most of the time vs a flop bet. Given that their checking range also has more strong hands than when they are IP, Hero can expect the flop to go x/x more often, realizing equity for free.

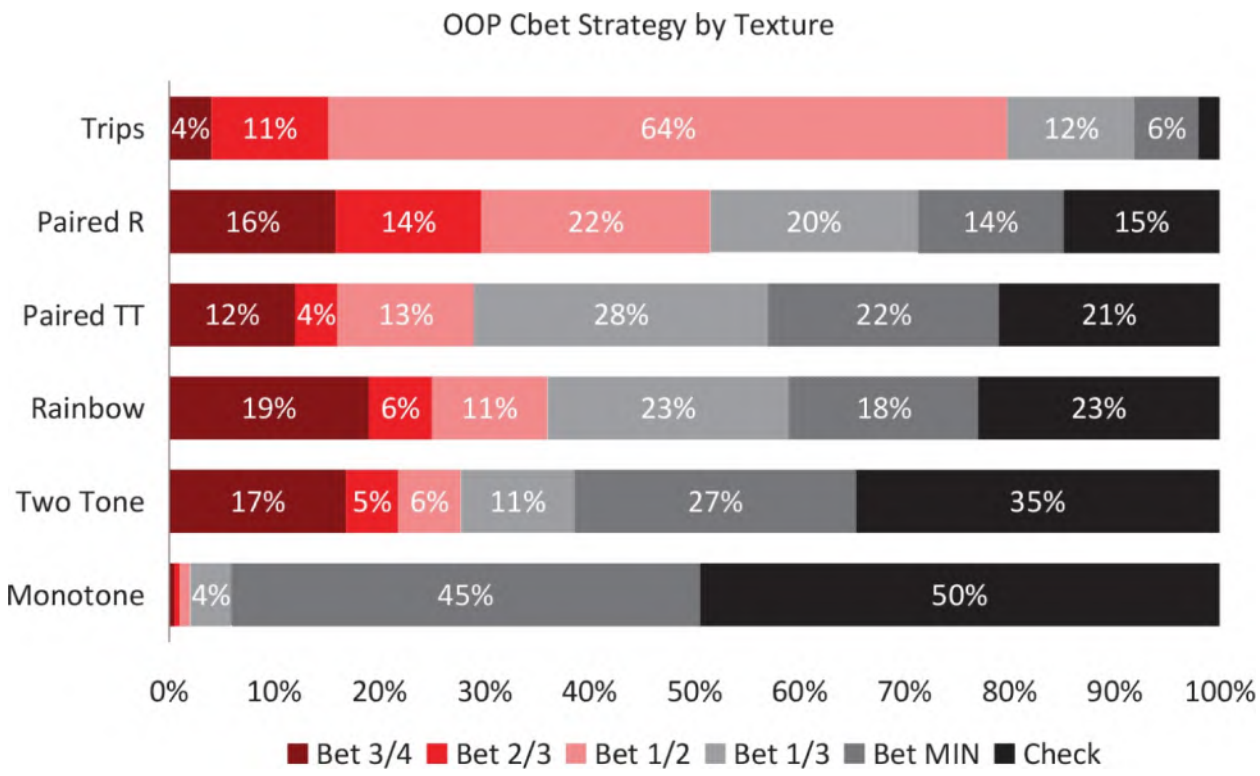


Diagram 74

The texture most c-bet is trips. Hero has more overpairs and premium overcards that will turn big pairs more often than IP, and IP's range has many suited, connected type hands that are complete trash and often have to fold. Paired boards are c-bet very often and, contrary to IP vs BB situations, Hero as OOP uses big bet-sizes on paired boards, particularly on low rank flops. When the Villain is in the BB, their range is much wider and can connect with trips in multiple ways, but when they are on the BN, the number of hands that make trips is way lower. This creates a situation where IP's range will be capped, while OOP is uncapped, allowing OOP to use a large bet-size, particularly on low and middle boards.

The OOP player has a significant polarization advantage on rainbow flops, allowing them to use bigger sizes more often. On the two-tone flops, the equity and EQR of many of OOP's strong hands gets reduced due to the presence of the flush draw, resulting in a reduced c-betting frequency. Monotone boards improve IP's equity distribution substantially. This results in OOP using a small bet and c-betting only about 50% of hands.

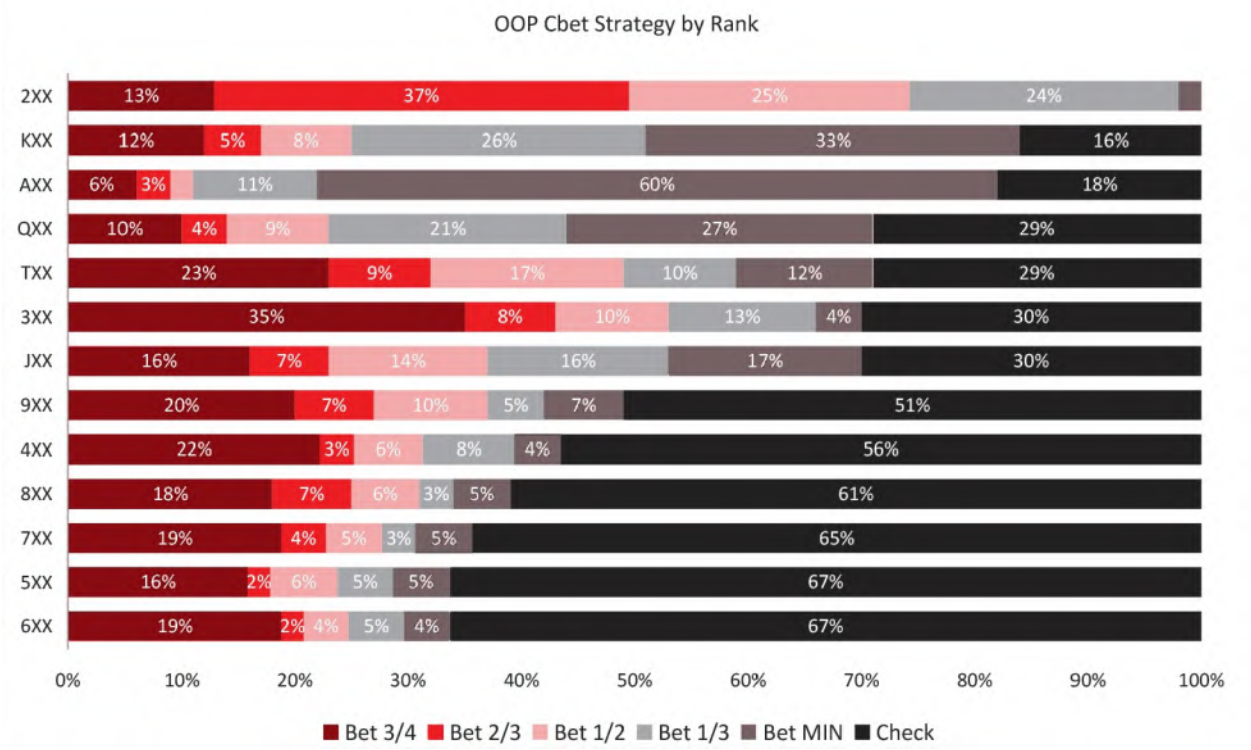


Diagram 75

On Axx and high card flops, OOP has the range advantage and c-bets most of the time, while on middle and low flops the equity distributions are symmetric, resulting in OOP playing a lot more passively.

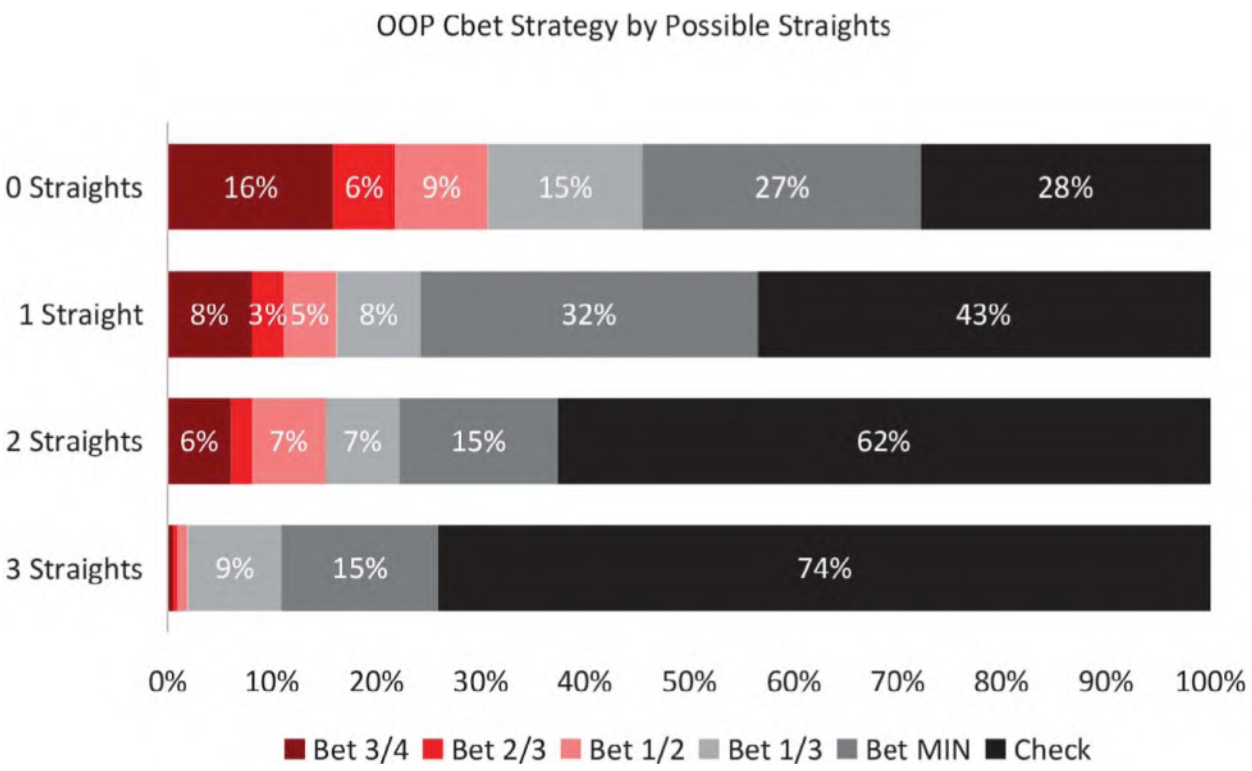


Diagram 76

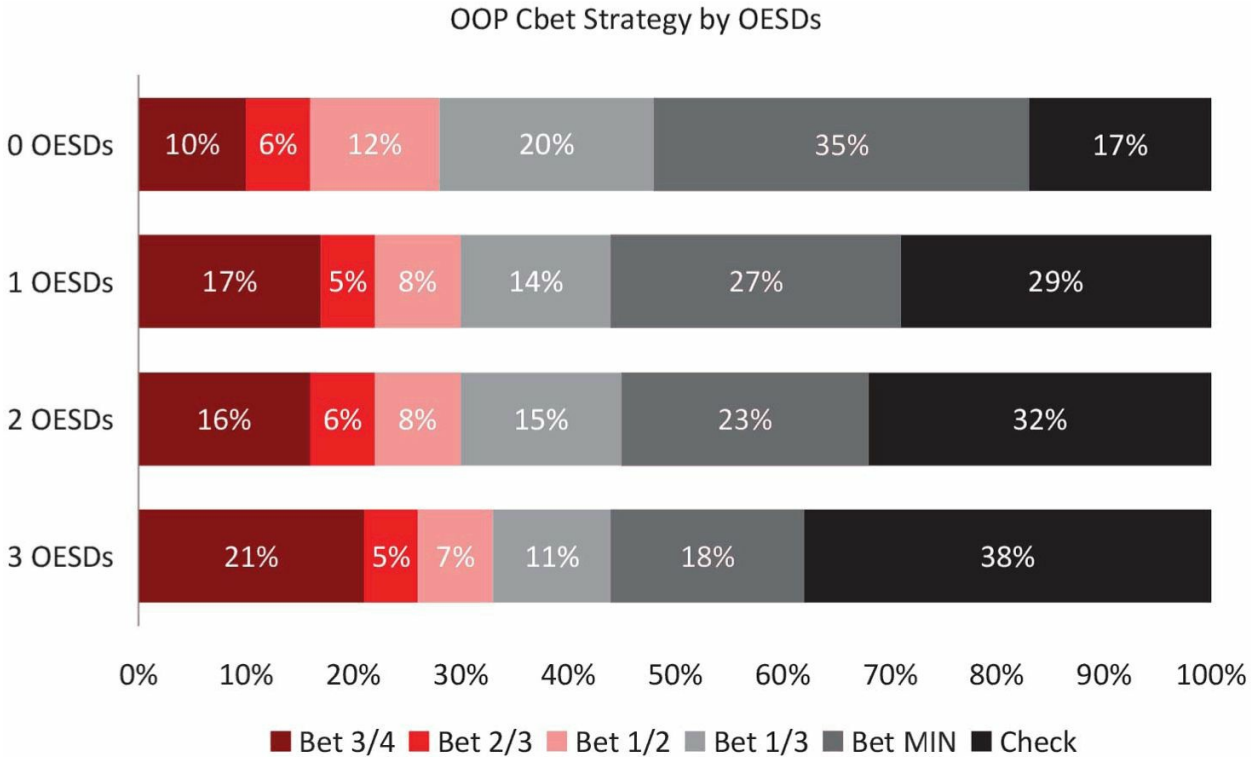


Diagram 77

IP's range connects well on boards where there are possible straights and boards with straight draws, because the BN's cold call range has a lot of suited connectors and middle to small pocket pairs. For this reason, OOP plays more passively on this type of dynamic board, while static disconnected boards with no possible straights are better for Hero because they don't improve IP's range as much.

C-betting in 3-bet Pots

In a 3-bet pot, the ranges in play are generally narrower than in a single raised pot. Additionally, the way pre-flop ranges are constructed generally result in a more polarized post-flop equity distribution for the pre-flop aggressor and a more condensed distribution for the pre-flop caller. In this section, our study will focus on both IP and OOP c-betting strategies, with starting stacks of 40bb and a typical MTT 12.5% ante structure with pre-flop GTO ranges. I recommend going over Chapters 8 and 9 and reviewing the pre-flop 3-betting and calling ranges for the following match-ups.

40bb Effective Stacks: Hero is the pre-flop aggressor and the Villain is the caller.

IP 3-betting
BN vs CO / BN vs MP / BN vs EP / CO vs MP / CO vs EP / EP vs EP

OOP 3-betting
BB vs BN / BB vs CO / BB vs EP / SB vs BN / SB vs CO / SB vs EP

Post-flop SPR: 1.7 to 2.
C-bet-sizes: all-in, 1/2-pot, 1/3-pot, 1/4-pot.

Hero Position	Villain Position	Hero EQ	Hero EV	Hero EQR
BN	CO	56.4%	62.4%	111.0%
BN	MP	56.0%	62.0%	111.0%
BN	EP	54.4%	62.8%	115.0%
CO	MP	57.0%	63.7%	112.0%
CO	EP	54.4%	62.3%	115.0%
UTG+1	EP	56.6%	62.3%	112.0%
Average		55.9%	62.7%	112.0%

Table 120: Hero Stats (IP 3bet)

Hero Position	Villain Position	Hero EQ	Hero EV	Hero EQR
BB	BN	53.2%	52.8%	99.0%
BB	CO	53.2%	53.1%	100.0%
BB	EP	53.1%	55.0%	104.0%
SB	BN	56.5%	57.0%	101.0%
SB	CO	55.6%	55.2%	99.0%
SB	EP	55.0%	55.9%	102.0%
Average		54.5%	54.6%	100.0%

Table 121: Hero Stats (OOP 3bet)

Something very interesting is how the solver manages to create such similar post-flop situations from the different pre-flop ranges, particularly when IP 3-bets. The players' equities, EQR and EVs are uniform across the board. In fact, the EQB are also similar and this results in IP c-betting strategies being uniform for most of the match-ups.

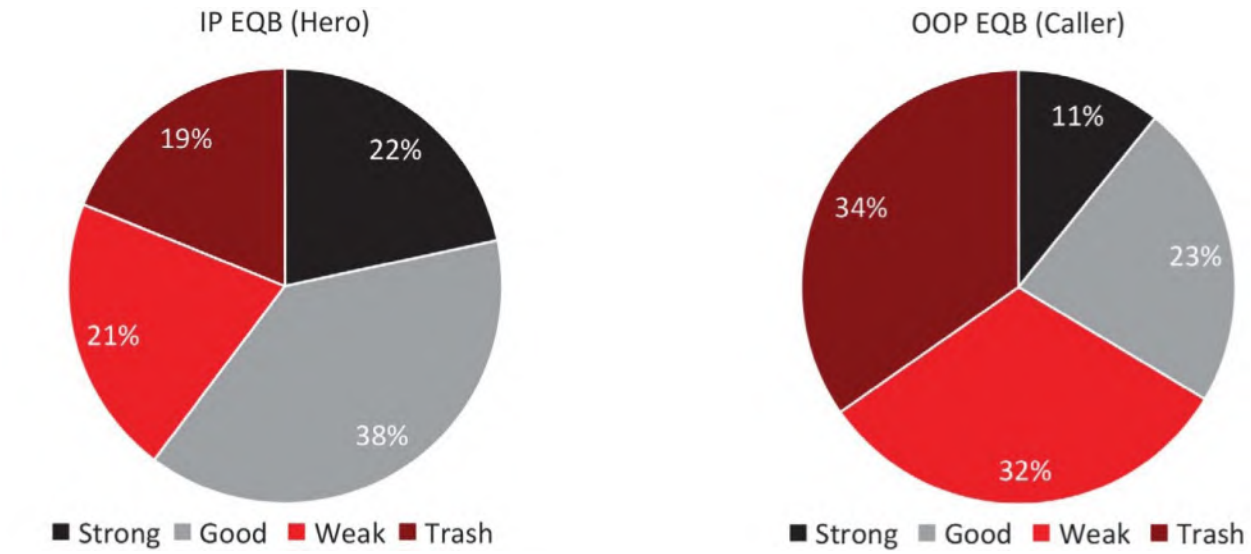


Diagram 78: Hero IP 3-bet Equity Buckets

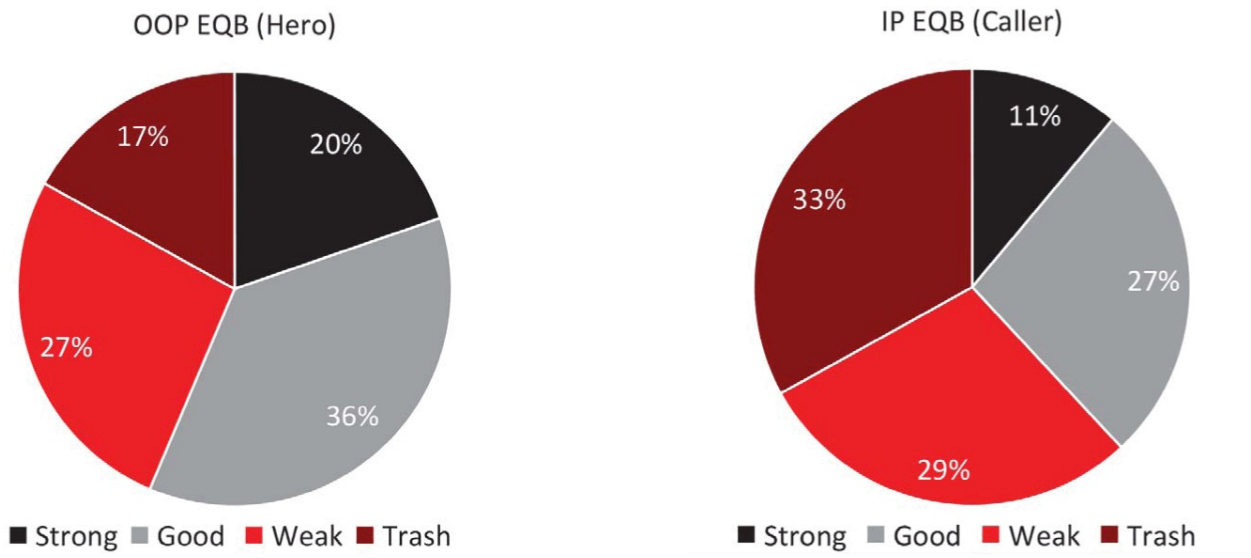


Diagram 79: Hero OOP 3-bet Equity Buckets

In 3-bet pots, the pre-flop aggressor will generally have a polarization advantage, with almost a 2-to-1 strong hand advantage, a 1.5-to-1 good hand advantage and with 1/3 of the calling player's range being trash hands. This equity distribution results in small bet-sizes being generally preferred, particularly when Hero is IP.

IP 3-bet Strategy Overview

After 3-betting IP, Hero's strategy on the flop will be to mostly use a small bet-size. The strategy

could easily be simplified to only 1/4-pot bet. On average, IP checks back the flop 38% of the time. In my experience, most players tend to c-bet the flop way more than they should because they tend to always c-bet their air. This trend happens because the population does not x/r the flop in 3-bet pots as aggressively as they should, which allows IP to profitably c-bet trash hands. Therefore a good counter-adjustment from OOP would be to step up the x/r frequency in 3-bet pots.

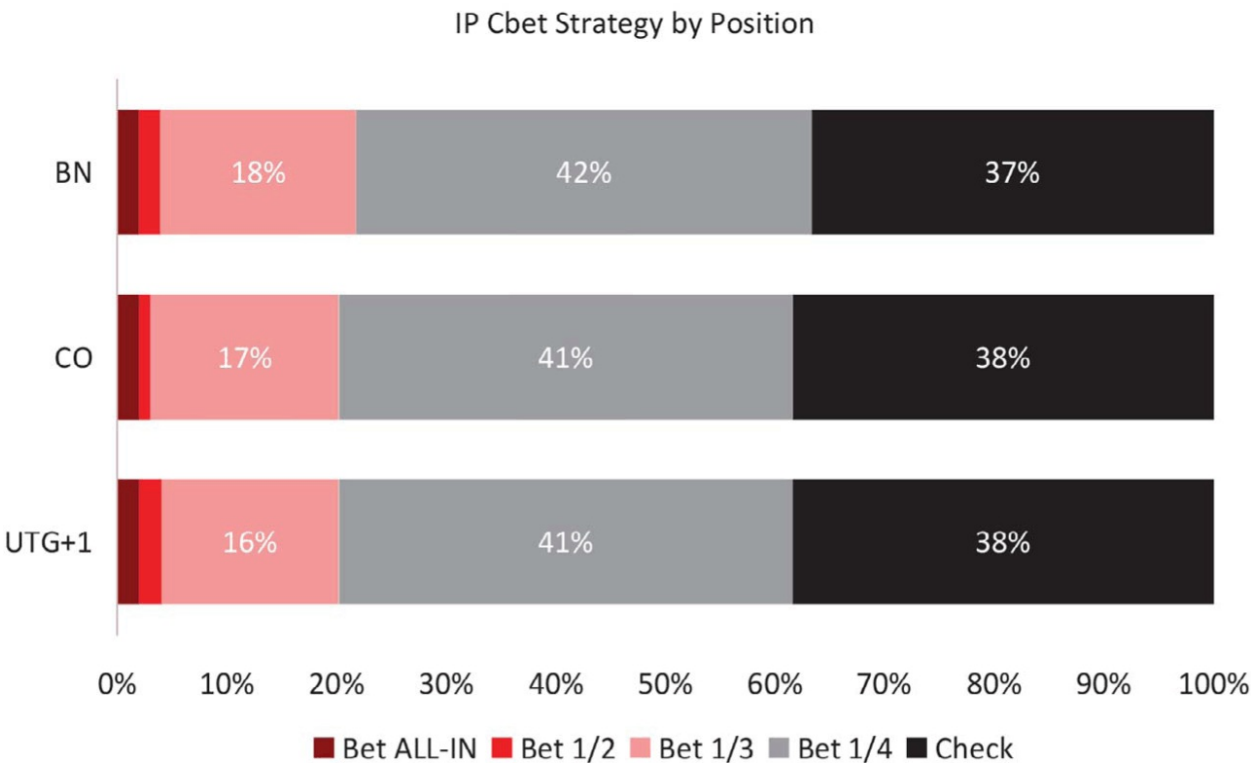


Diagram 80

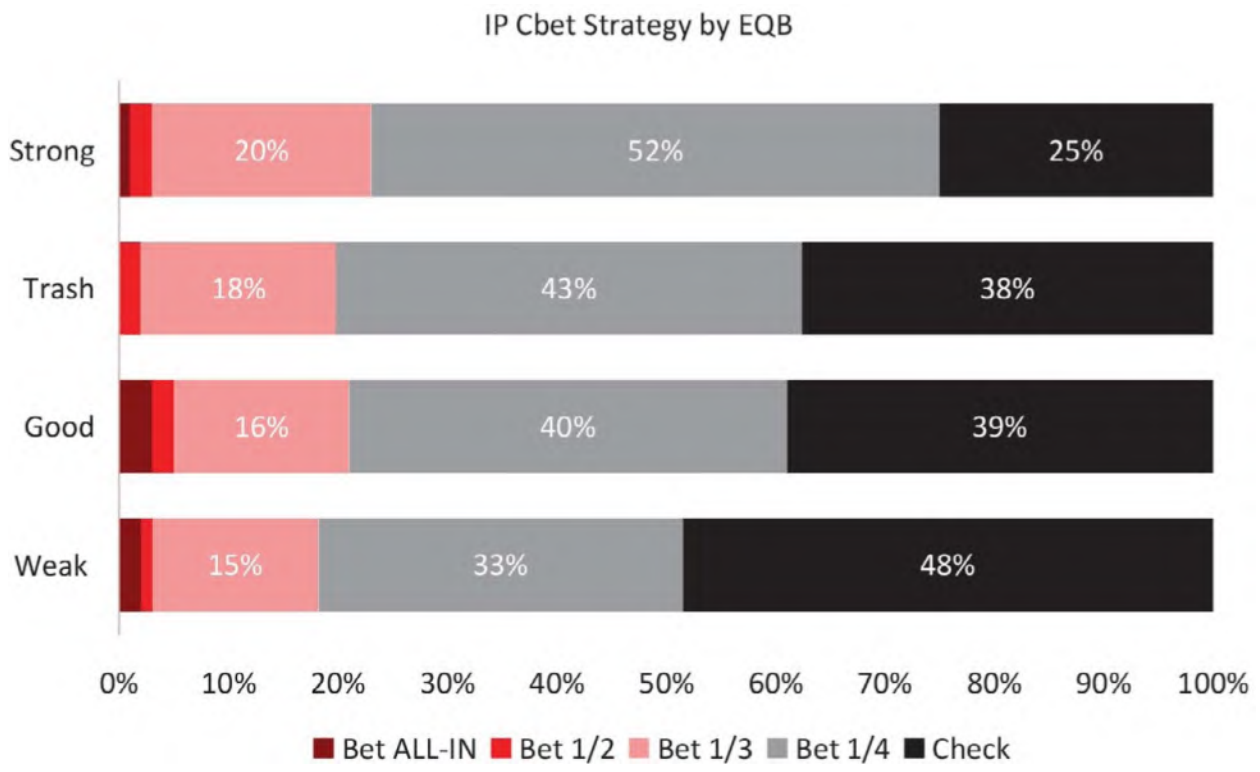


Diagram 81

Given that IP has a substantial checking back range, many strong hands are checked back, particularly when they block the Villain's continuing range. For example top set QQ on Q82r gets checked back 68% of the time.

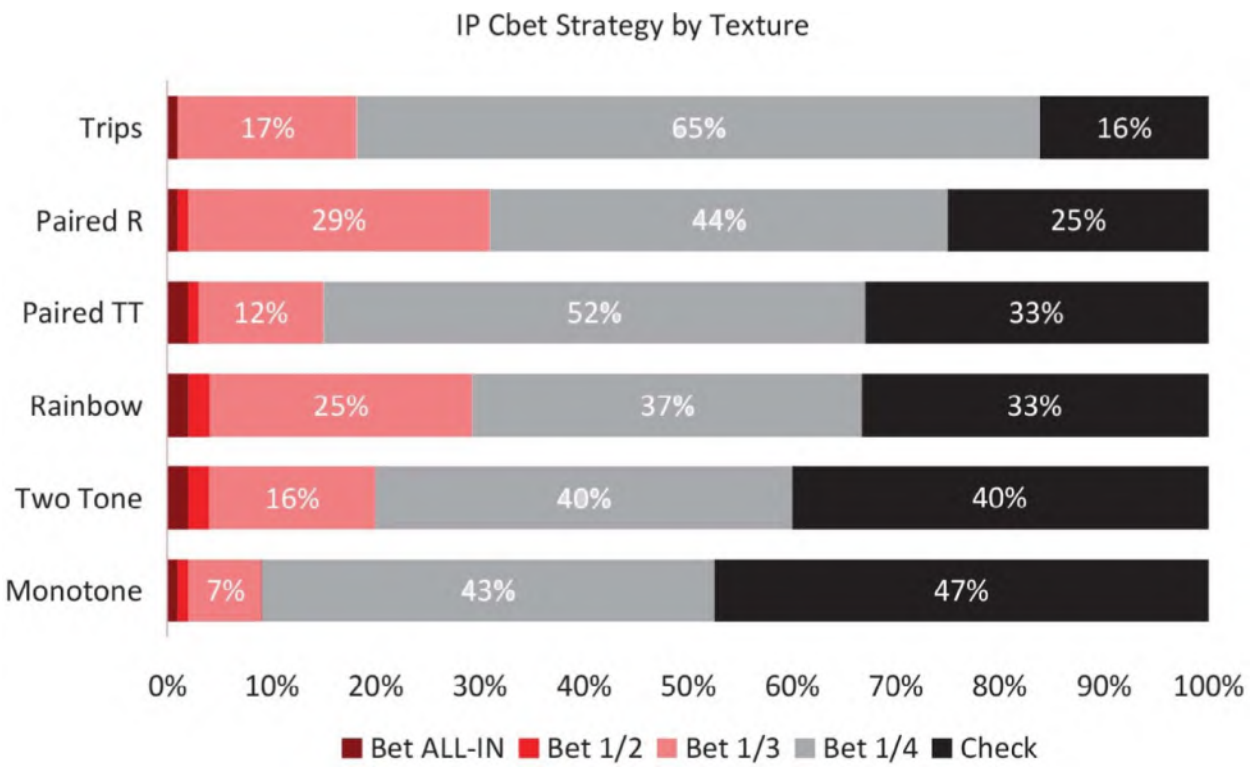


Diagram 82

Trips and rainbow paired flops are the most frequently c-bet textures, with two-tone and monotone flops being the least frequently c-bet. On two-tone flops, OOP has a great spot to x/r with many flush draws, which would force Hero off the pot. For this reason, two-tone flops are checked back at a high frequency, allowing many of IP's good and weak hands to realize equity.

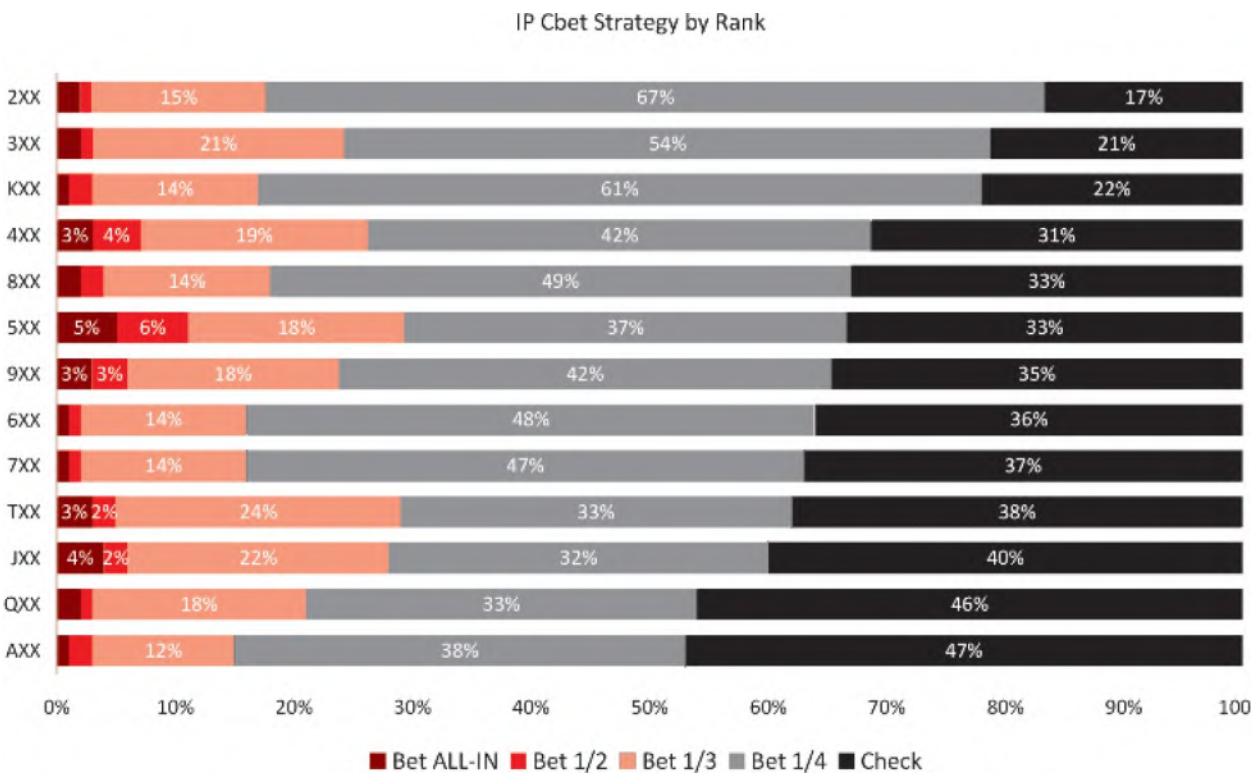


Diagram 83

Low and Kxx boards are the most frequently c-bet ranks. Middle boards with possible straight draws are checked back with a medium frequency because they connect very well with OOP's range, but IP still has plenty of overpairs in their range. Qxx and Jxx flops, on the other hand, connect well with the pre-flop caller's range and also demote many of IP's hands to second or third pair, making IP more incentivized to check back.

Axx is an interesting board. The population tends to c-bet Axx flops pretty much 100% of the time. However, in simulations, Axx boards are static and polarize OOP's range as they will either have a strong hand, a medium strength hand that cannot call multiple bets, or a lot of trash that cannot continue on the flop, but won't improve much on most turns. Given those hand values will not change much and, with a low SPR, all the money can easily go in on two streets. For this reason, checking back the flop in order to get additional information from OOP when they have to act on the turn makes a lot of sense, allowing IP to protect the flop check back range with plenty of strong hands, while also realizing equity with medium strength hands.

OOP 3-bet Strategy Overview

On average, Hero realizes less equity when OOP compared to IP. When Hero is IP, it is possible to check back a weaker range that will likely improve on the turn, while from OOP, Hero's

checking range has to be balanced enough to face any aggression from IP. Some of the time Hero also has to use bigger bet-sizes when OOP so as not to give too good a price to IP to continue with a wide range. Using bigger bet-sizes also helps Hero by reducing the SPR, and with it the positional disadvantage.

The SB's 3-betting range is, on average, a bit stronger than the BB's range. This allows Hero to c-bet slightly more frequently when in the SB compared to the BB.

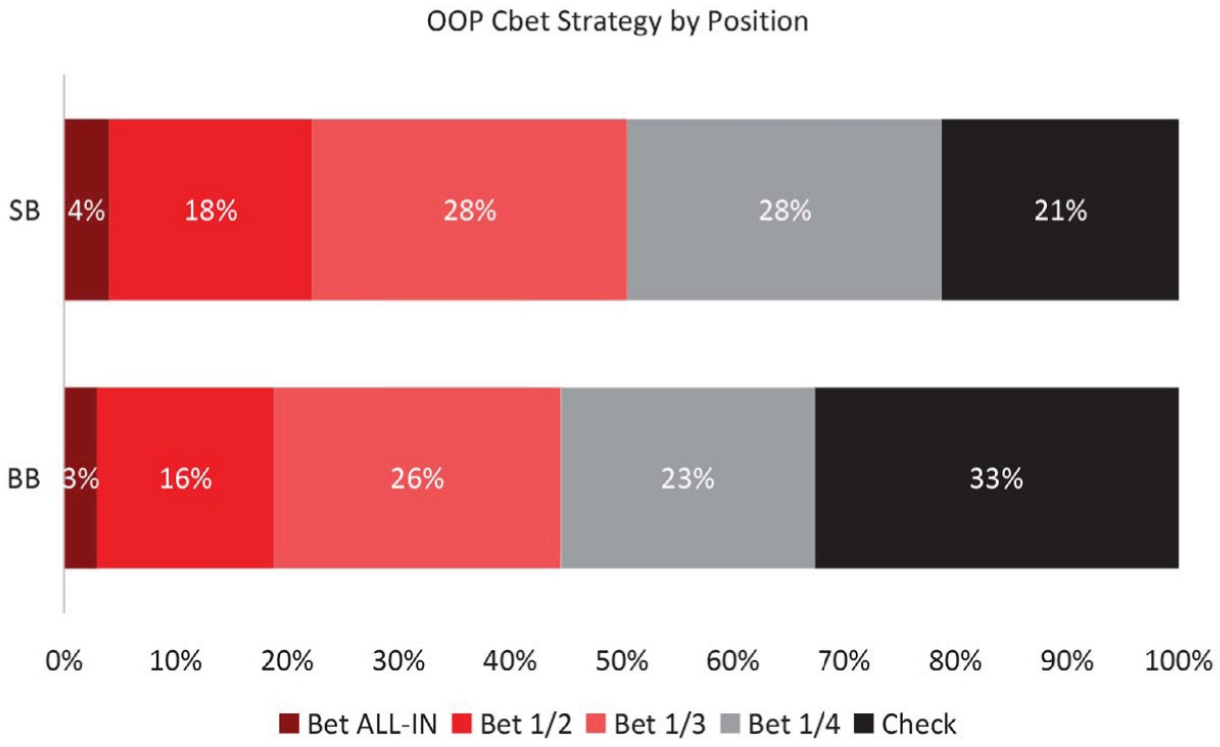


Diagram 84

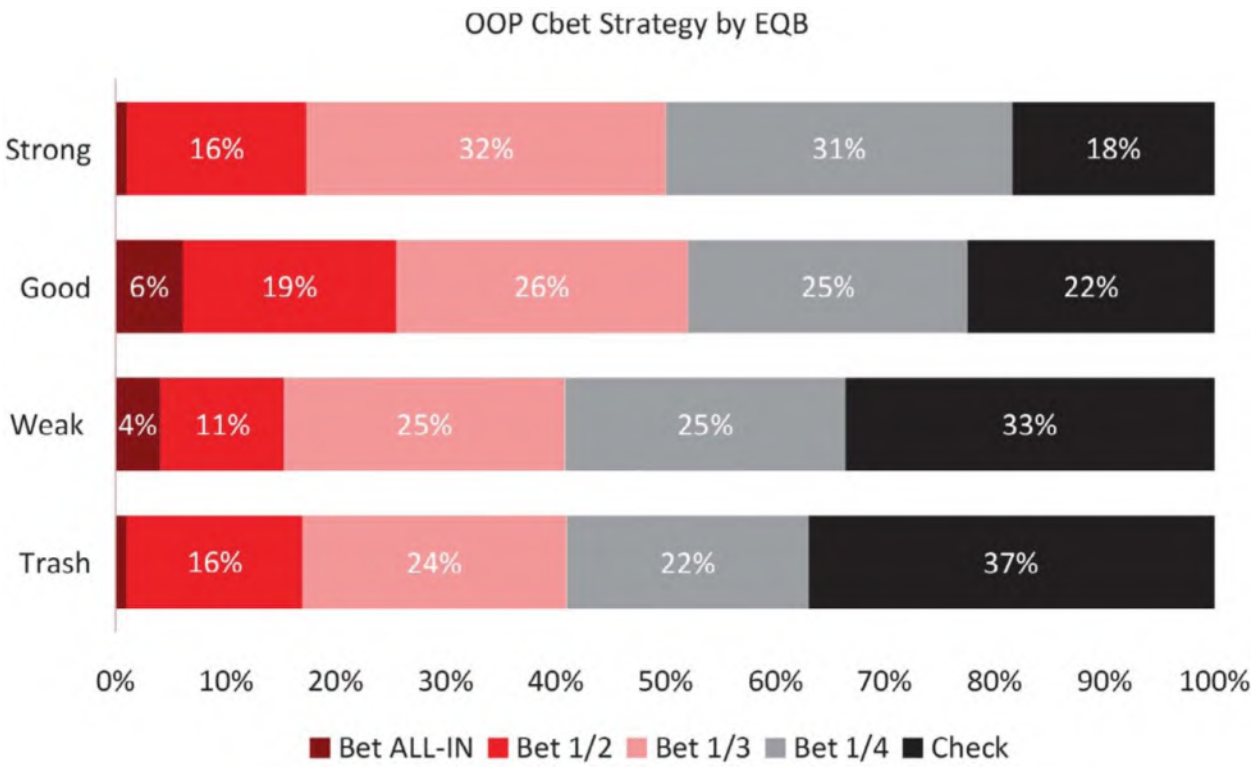


Diagram 85

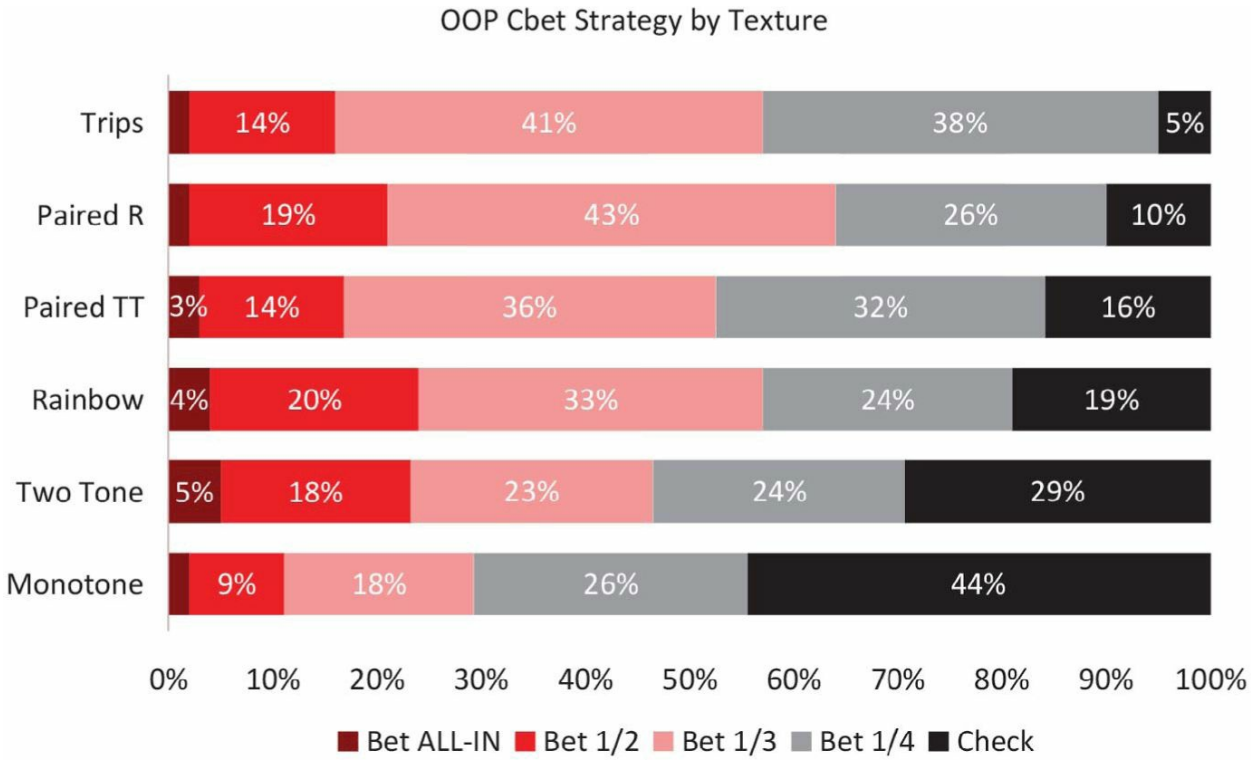


Diagram 86

When OOP, Hero c-bets at a higher frequency across almost all flop textures, except for monotone boards which will be c-bet at a similar frequency. From OOP, Hero will use bigger bet-sizes compared to when IP.

After 3-betting from the blinds, Hero likes to c-bet low boards at a high frequency, given they have a stronger range with many overpairs. Middle boards get checked more often when they have possible straights and straight draws. Qxx, Jxx and Txx boards are some of the most checked boards because they connect well with IP's range.

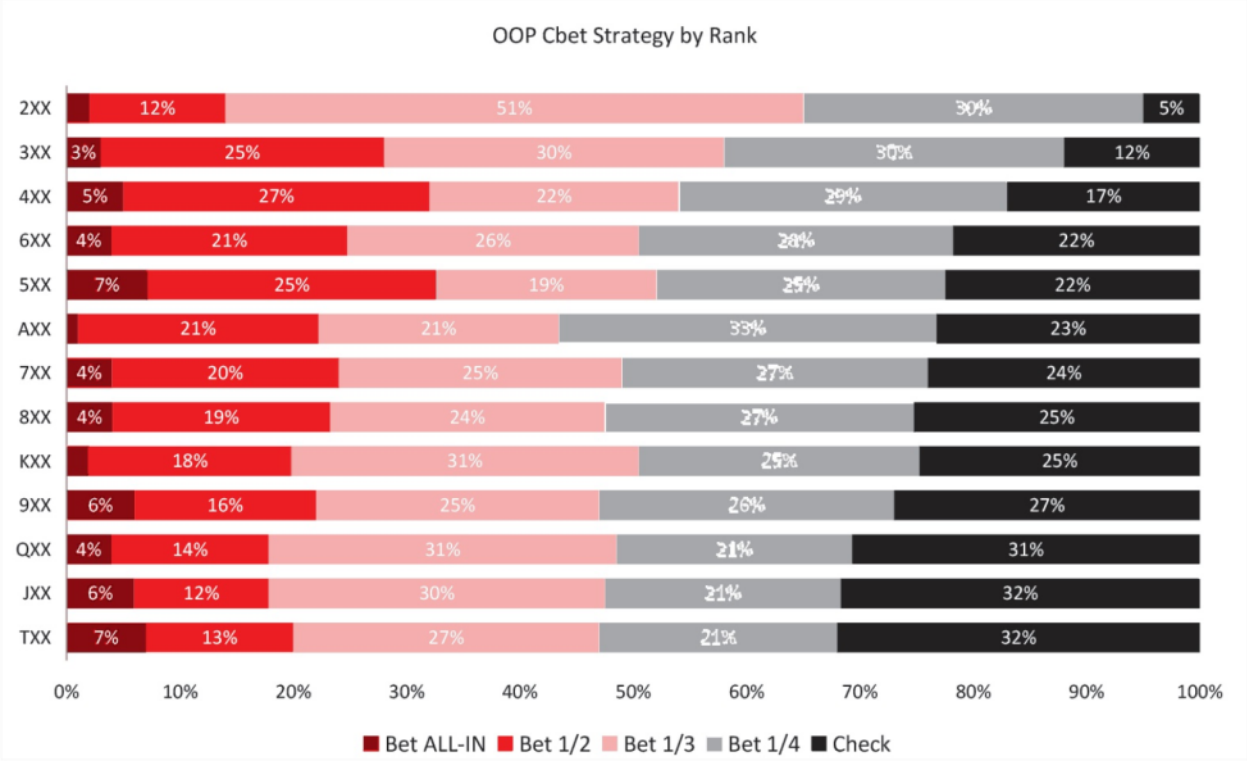


Diagram 87

An interesting difference is seen on Axx boards that get c-bet 77% of the time when Hero is OOP but only 53% when Hero is IP. In both situations, the players' equity distribution is similar, and so the main difference seems to be that now, playing OOP, Hero doesn't want to give the option to the Villain to have a free turn when IP. If the action goes x/x on the flop, it is Hero who will have to act first on the turn, giving away more range information. So, Hero decides to mostly bet on Axx flops and force IP to fold some weak hands on the flop with a higher frequency, avoiding complications by taking a passive line too often.

C-bet Defense

In no-limit hold'em, c-bet defense is highly susceptible to bet-sizing. Some players like using MDF as pseudo-GTO strategy, but as we have already pointed out, while this number could in some instances serve as a rough guideline, it does not take equities and range distribution into account.

Basing your entire strategy on MDF will be highly detrimental.

For example, in the BB vs UTG 40bb situation, if UTG bets 1/3-pot then, according to MDF, the BB is supposed to defend 75% of the time. However, on a flop such as AQ3r, the BB's range has 70% trash hands and 10% weak hands. On average, the BB's trash hands have 16% equity against UTG, but the pot odds laid by UTG's bet-size are 20%. So even against the 1/3-pot bet-size, calling many of those hands will be -EV.

Raising would be even worse, as that puts even more money into the pot vs a strong range that will not fold enough to make the bluff profitable. In this situation, the BB's GTO defense strategy vs the 1/3-pot bet-size has them folding 58% and defending only 42% of the time, which is nowhere near the 75% MDF. On this flop, the UTG can get away with c-betting their entire range and there is nothing the BB can do to stop them from having a profitable bet with any two cards.

So, if you are holding something like a 96s with a BDFD, a weak king-high or a small pocket pair and have about 10-20% equity, you should simply fold even if the Villain is betting ATC. Your pre-flop call was profitable and there will be other flops where your range will be much stronger and you will either connect a strong hand, have a better bluffing opportunity, or your opponent will simply check back more often, allowing you to realize more equity.

Never try forcing matters! Your goal is not to try to win every hand you play, but to play each hand in the most profitable way. If calling and raising are -EV plays, then folding, which is always 0 EV, will be the highest EV play.

You must be disciplined enough to make the right play.

When facing a bet, it is of vital importance to always consider the Villain's range that will take that specific line. For example, when facing a min-bet, your pot odds will be amazing, but the Villain will use a different range composition compared to when they bet the size of the pot. This will have an effect on your strategy because your hands will have different equities depending on how the Villain constructs their various betting ranges. If the Villain is the type of player who will always c-bet strong hands and check back medium strength hands in a given spot, many of the bottom of range hands you would defend against a GTO player will have way lower equity against this unbalanced strategy. You can exploit this poor range construction by overfolding the

flop.

In this section, we will examine in detail the BB vs IP c-bet defense match-up in a single raised pot with 40bb stack depths. Our focus will once again be on BB vs BN and BB vs UTG, so we can compare the BB's strategy against both the widest and the tightest possible ranges. In this match-up, IP can c-bet 1/4-pot, 1/3-pot, 1/2-pot, 2/3-pot and the BB has the options to x/r 50% pot, x/r 25% pot, call and fold. (The 25% raise size results in a smaller bet-size than 2x the original bet-size when IP uses the 2/3-pot bet, so it was rounded up to a min-raise in the GTO simulations).

40bb Single Raised Pot BB vs IP

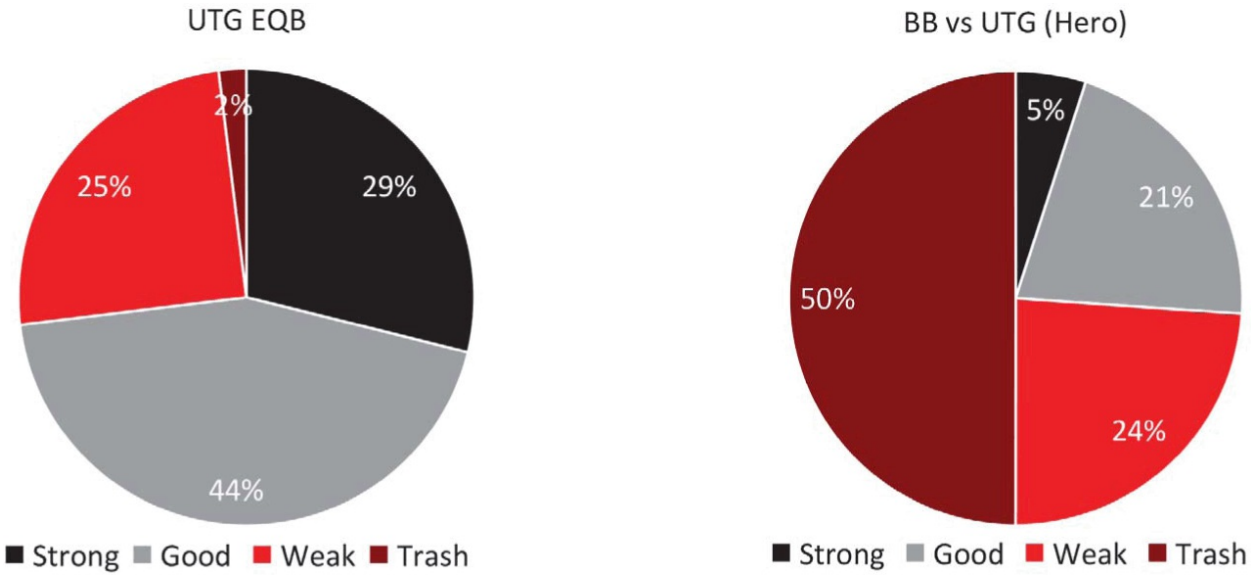


Diagram 88: BB vs UTG

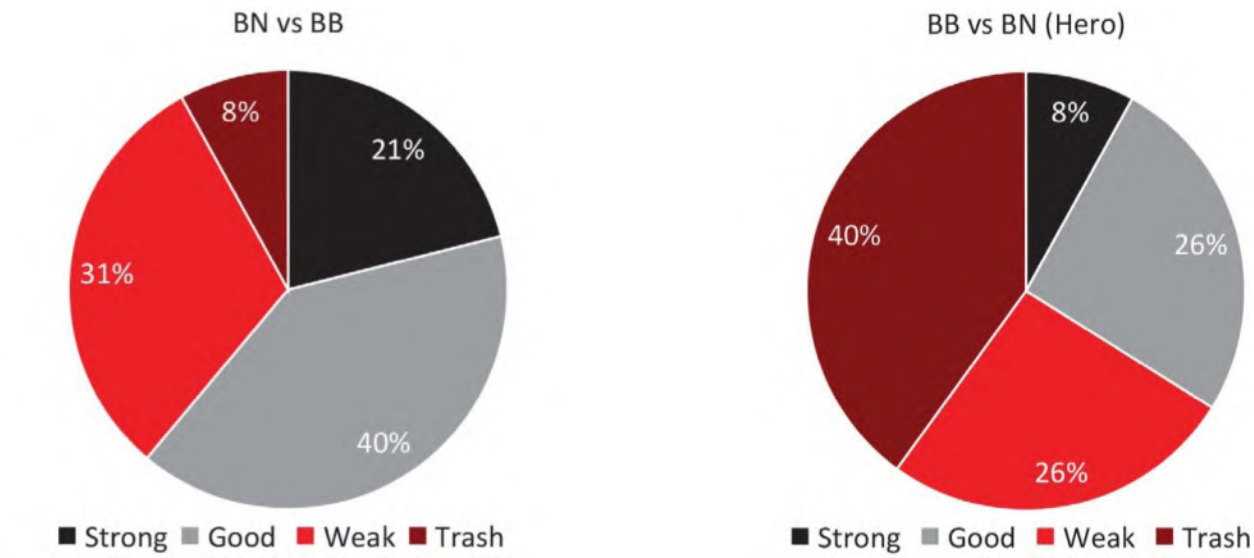


Diagram 89: BB vs BN

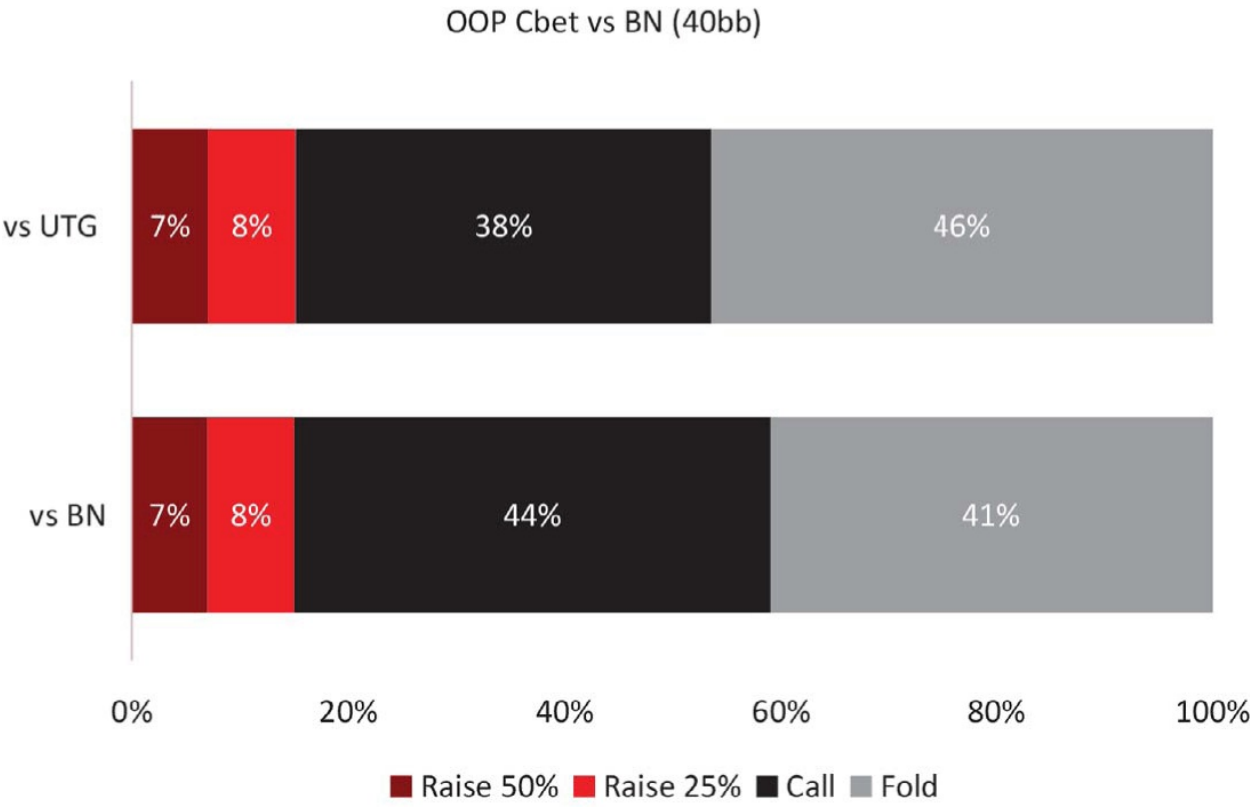


Diagram 90

The BB's range is weaker against UTG than against the BN. This results in the BB folding on average more hands when facing a c-bet from UTG than when facing a c-bet from the BN.

BB vs IP: Strategy Overview

In general, you want to x/r to a larger size when the Villain bets small, and x/r smaller when Villain uses a larger bet-size. The BB needs to create some sort of indifference for IP's c-betting range. If the BB uses only the 25% x/r size, this could create a bias in IP's strategy because the weaker hands will never be priced out of the pot, as the total cost of bet/calling a hand against a flop x/r will always be smaller when Villain decides to min-bet the flop.

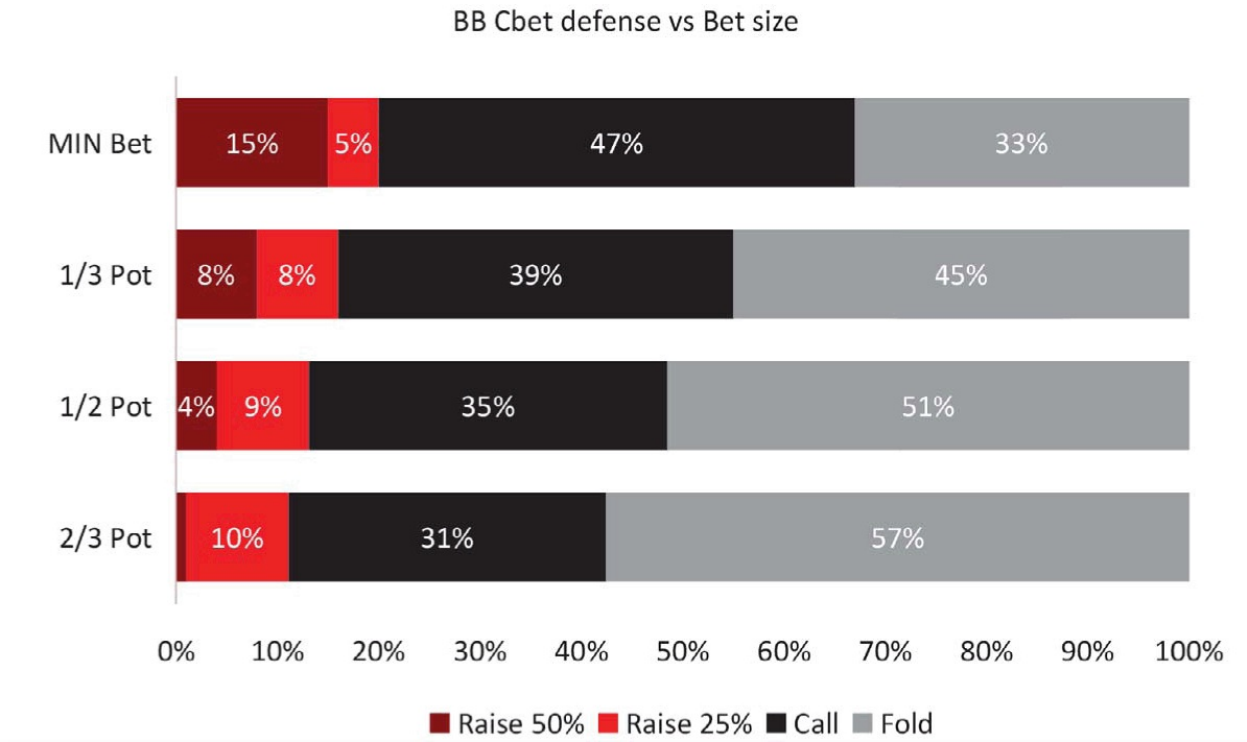


Diagram 91: BB vs UTG

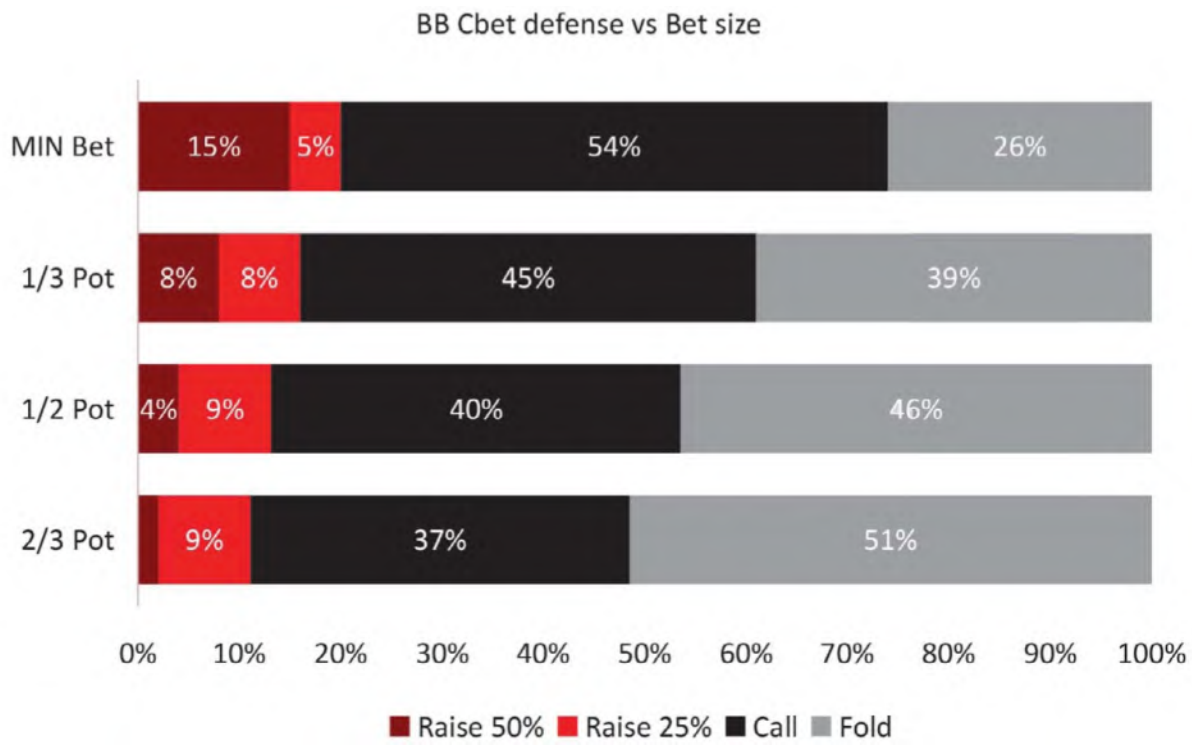


Diagram 92: BB vs BN

Increasing the raise size when the Villain bets small keeps their lowest equity hands indifferent to calling and folding. Similarly, when IP uses a large bet-size, the BB does not have to make a large raise that could be over-committal. Often a check-min-raise suffices. An exception to this rule would be in the case of all-in raises, as they get a better risk/reward ratio when IP's bet-size is large.

The smaller IP's bet-size, the more depolarized their betting range will be. This allows the BB to increase their overall x/r frequency.

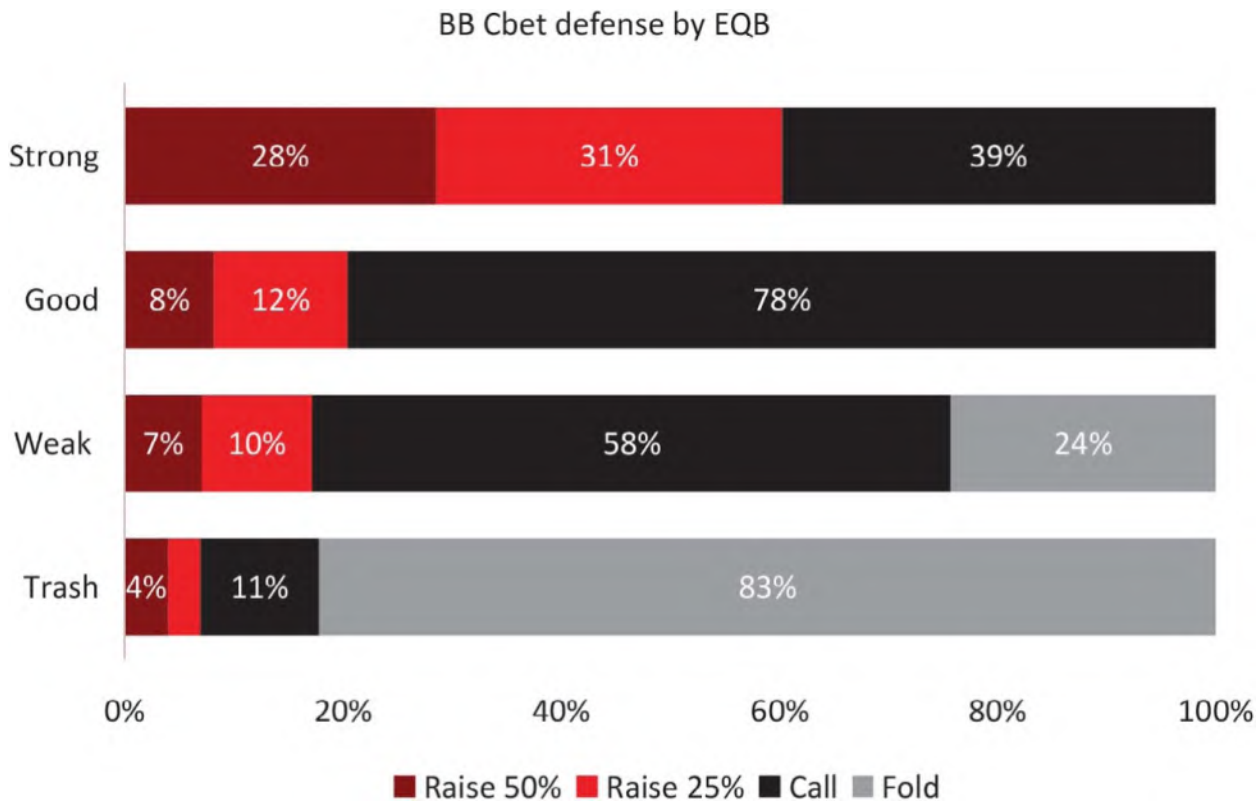


Diagram 93: BB vs UTG

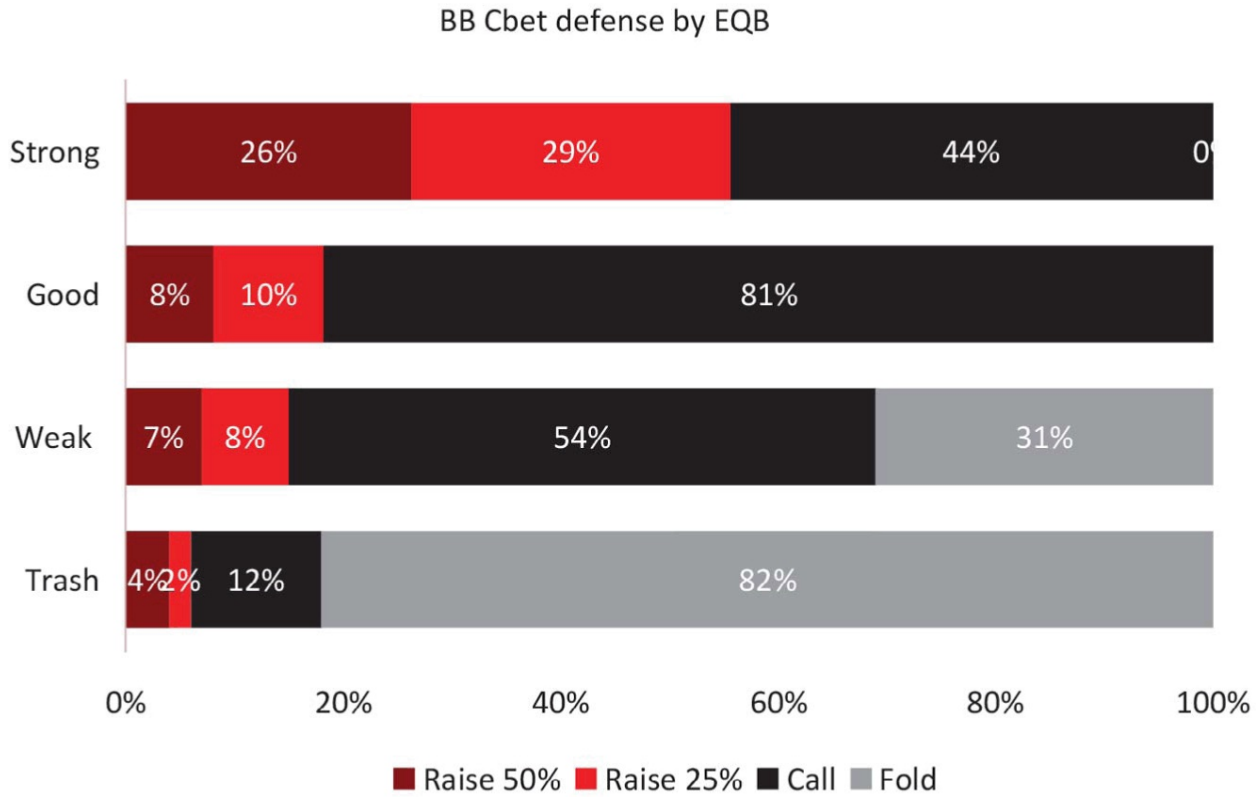


Diagram 94: BB vs BN

The BB's folding range is composed mostly of trash, so the BB's total number of trash hands is the main factor when determining their overall folding frequency.

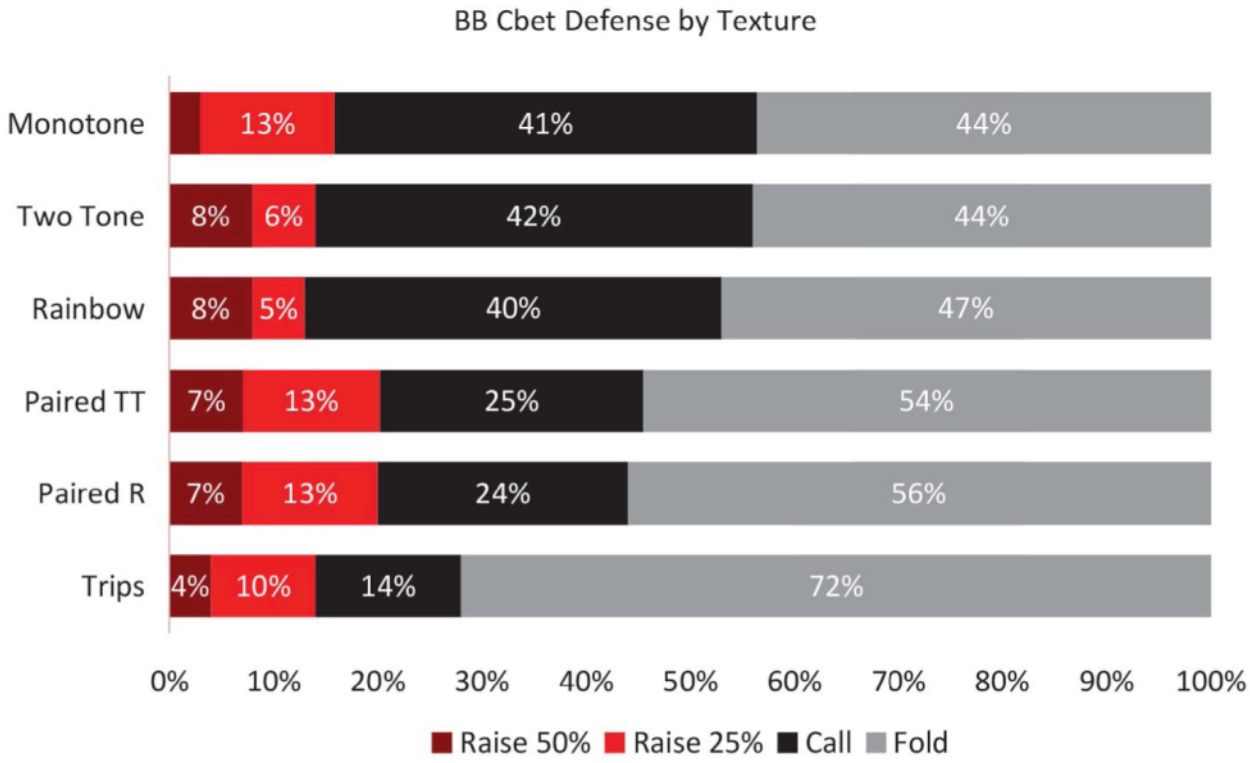


Diagram 95: BB vs UTG

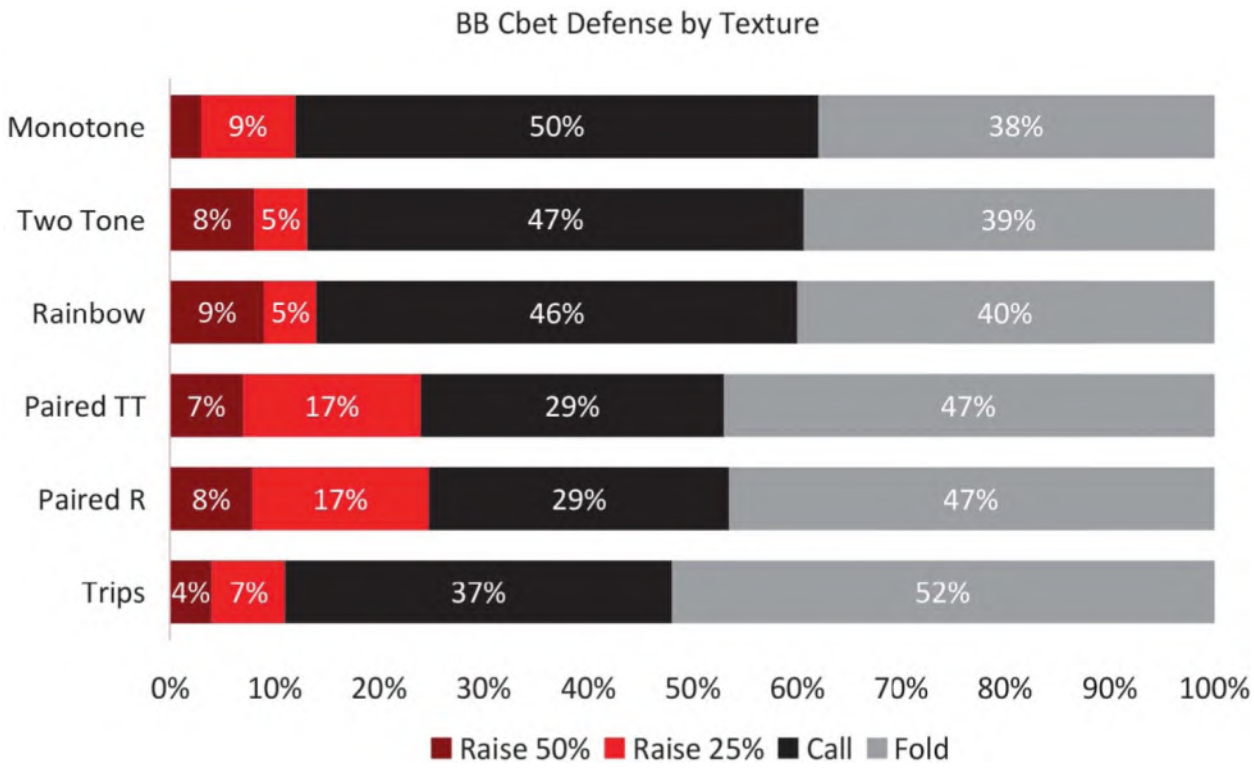


Diagram 96: BB vs BN

Strong hands mostly want to x/r the flop, but many are also x/c with the intention to x/r on a later street. This keeps the BB's x/c range protected. Good hands mostly want to call, but some of them want to x/r, particularly the combos that might need protection and unblock the Villain's continuing range, such as top pair in middle boards, bottom two pair on high boards and combo draws that would benefit from getting all the money in on the flop or reducing the SPR so they cannot be easily pushed off the pot on the turn.

Weak hands are mostly x/c, but almost 1/3 of them get folded and about 15% get x/r. Trash hands are mostly folded, but some get x/c and a few of them work well as x/r bluffing combos.

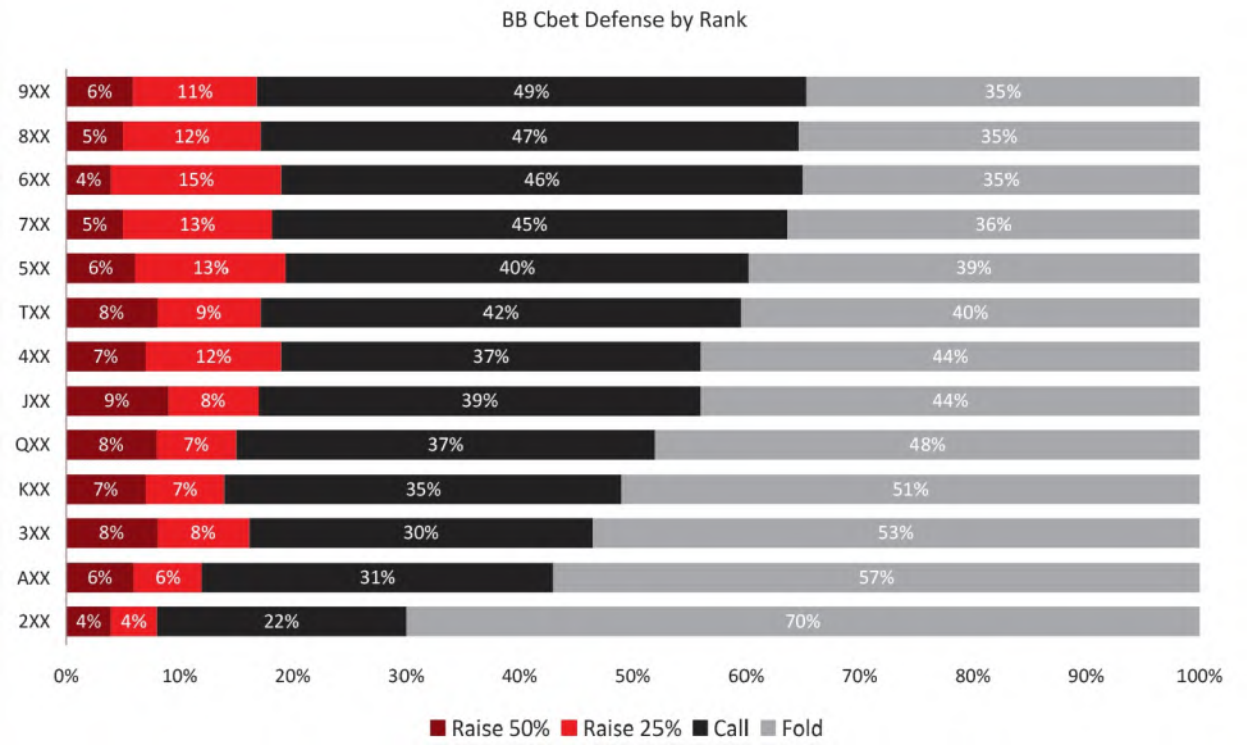


Diagram 97: BB vs UTG

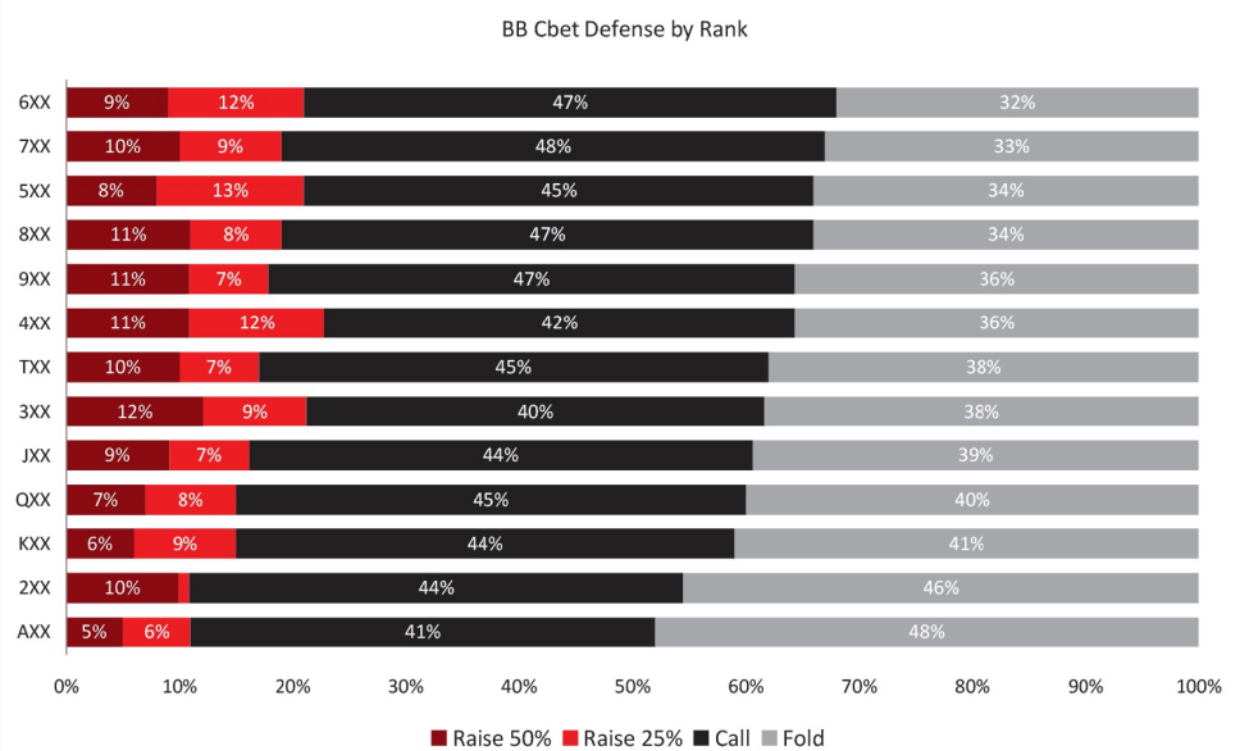


Diagram 98: BB vs BN

General BB C-bet Defense Guidelines

♦ Avoid splitting your range early in the hand unless you have many strong hands you can distribute in a x/r and x/c range.

♦ Generally use large x/r bet-sizes against small c-bets, and small x/r sizes against large c-bets, except for against all-in bets that give a better risk:reward ratio.

♦ In general, flop x/r ranges are polarized, including made hands that are happy to get in vs a 3-bet and hands that are fine raise/folding. A losing proposition is to x/r good hands that are not good enough to get in on the flop while at the same time are too good to fold vs a raise. Think ahead and avoid putting yourself in tough spots.

♦ If your hand has a lot of equity but not too much showdown value, or if it is vulnerable to losing a lot of value in future streets, consider playing aggressively with the intention of getting the money in while your hand is still valuable.

♦ The deeper the stacks, the stronger the average hand you need to x/r the flop. Good draws that can be barreled across various streets increase in value.

♦ When a x/r is a possible strategy, always consider the blocker effects. A value hand that does not block the Villain's continuing range makes a better x/r than one that does. For example, 44 on 9♥8♥4♥ makes a better x/r than 99. The opposite is true for bluffs. A bluff combo that blocks the Villain's continuing range is more valuable than one that blocks the Villain's bluff combos. If your hand blocks both bluffs and value, then try thinking about other variables that could sway your decision one way or the other.

♦ It is tough to x/c bottom pair across multiple streets, especially if the pair is small. Consider putting some of your bottom pairs in your flop x/r range.

♦ A-high and K-high are decent hands in many spots. Don't be so quick to give up on them on the flop, especially if your opponent bets small.

♦ If your range has a lot of trash hands, you should fold a lot of it vs a c-bet, regardless of your opponent's bet-size and the MDF.

♦ Don't try to represent a small value range and hope your opponents will lay down a big hand. That just won't happen often enough.

♦ Always be aware of the Villain's bet-size and pot odds offered. Be realistic about your outs and equity.

♦ Your flop x/r range won't necessarily consist of your strongest hands but, instead, hands that benefit from lowering the SPR and that have the right blockers (forward and reverse).

♦ Don't be afraid to play aggressively on a flop where you have a lot of strong hands in your range.

♦ Flush draws and OESD are good hands, but they are not the nuts. You don't have to x/r the flop every time you have a decent draw. It is important to have good board coverage in your x/c range too.

♦ Before snap folding your hand when you miss the flop, think for a few seconds about the way the equities are distributed on the flop. Consider how often the Villain should be betting the flop and how likely they are to fold to a flop x/r.

BB C-bet Defense Examples

Flop Strategy Example 1

BB vs 2/3-pot c-bet: BB vs UTG on A♥Q♦3♠ (40bb)

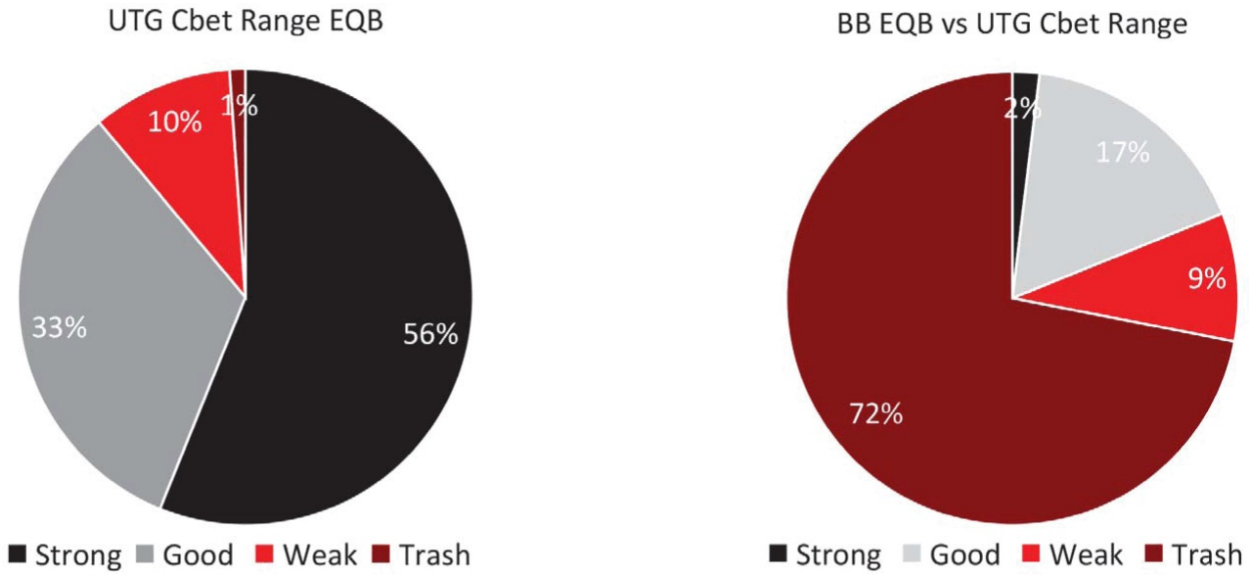


Diagram 99: BB vs 2/3-pot c-bet: BB vs UTG on A♥Q♦3♠ (40bb)

AQ3r is a horrible flop for the BB, who will only be able to capture 14% of the pot (half of their equity). In this match-up, most of the BB's range becomes trash hands with almost no hope to improve. With only about 3% strong hands, there isn't much the BB can do to stop UTG from c-betting their range for a large bet-size, which forces a fold 68% of the time.

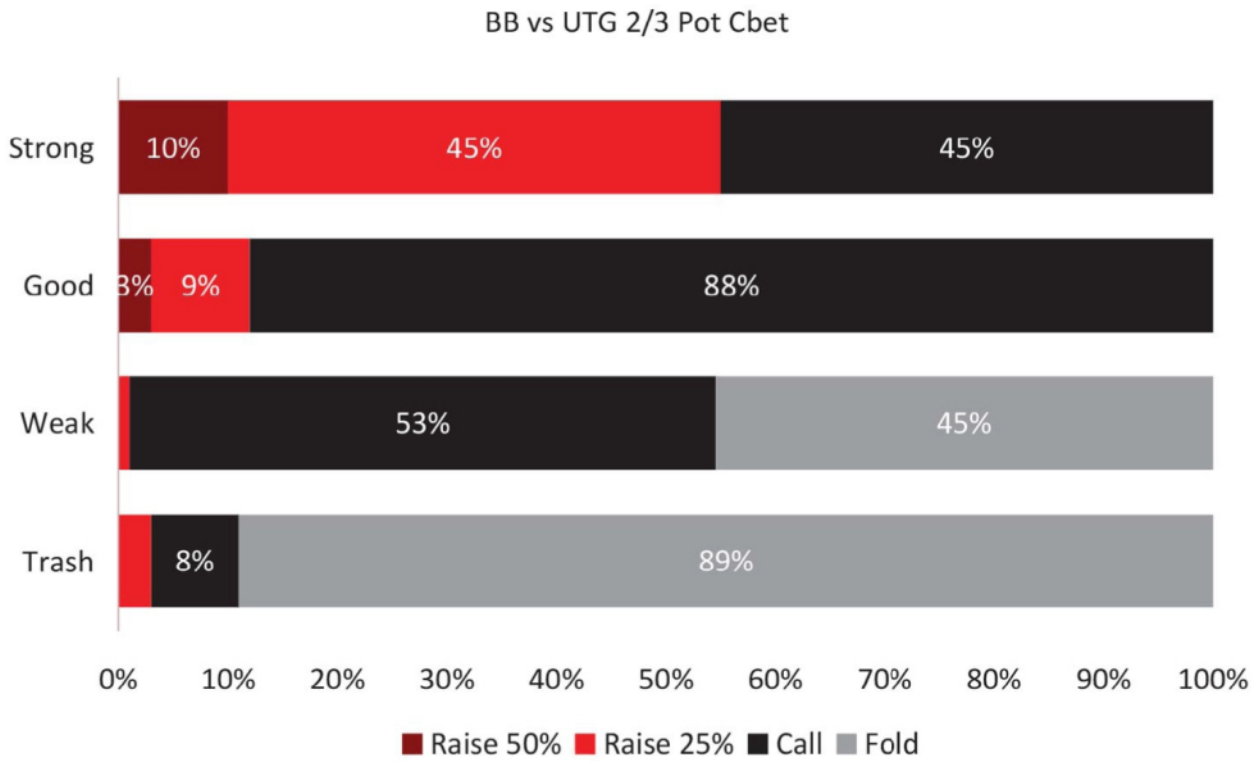


Diagram 100

Hand	% of Range	Equity	EV	EQR	Raise 50%	Raise 25%	Call	Fold
Sets	0.5%	90%	335%	374%	10.4%	87.1%	2.5%	0.0%
Two Pair	1.9%	85%	255%	300%	9.0%	32.8%	58.0%	0.0%
Top Pair	13.3%	67%	57%	86%	3.7%	11.2%	85.0%	0.0%
Second Pair	10.9%	50%	7%	14%	0.2%	1.2%	73.1%	25.5%
Pocket 2-3 (JJ-44)	7.3%	26%	0%	0%	0.0%	0.0%	0.0%	100%
Bottom Pair	6.0%	30%	0.4%	1.3%	2.2%	11.0%	20.6%	66.4%
Gutshot	10.9%	27%	1.5%	5.3%	1.8%	8.4%	45.4%	44.4%
King High	9.6%	16%	0%	0%	0.0%	0.0%	0.0%	100%
Air	38.6%	10%	0%	0%	0.0%	0.0%	0.0%	100%
Average		28%	14%	50%	1.0%	4.3%	26.6%	68.0%

Table 122: BB Strategy Breakdown vs UTG 2/3-pot c-bet on A♥Q♦3♠

- ♦ The only set the BB has is 33 and it gets x/r 100% of the time.
- ♦ Two pair gets x/r 42%, with Q3s being x/r 100%. A3s is x/r 1/3 of the time. AQo gets x/r 40% and AQs only gets x/r about 7%. A3 needs some protection and benefits from reducing the SPR, while AQs helps protect the calling range and can be x/r on a later street.
- ♦ Top pair is never folded on the flop and gets x/r about 15% of the time. If the BB happens to have AK, it gets x/r every time. AJ gets x/r 63% of the time and all the other Ax get x/r about 6%.
- ♦ Second pair gets folded 25% and never gets x/r. The strongest KQ gets called 100%. The middling QJ-Q9 get folded about 53% of the time when not having a BDFD and the weaker kicker Q8s-Q2s gets called 100%. In this set-up, mid pair low kicker has better equity than the mid pair high kicker because most of the time the kicker is live.
- ♦ Pocket pairs between the queen and the three are always folded. This includes some pocket pairs as big as JJ and TT that would make bad bluff-catchers, as they have only two outs which aren't even clean outs.
- ♦ Bottom pair is folded 66%. They can get called or even x/r sometimes as they have a lot more equity than a pocket pair such as 77. Any 3x can have up to 5 outs (another 3 plus the kicker). In this case, the weaker kickers are also more valuable than the high kickers, and hands such as K3s get folded 100%, while a hand like 53s can be x/r 43%, x/c 20% and x/f 36.5%. Usually bottom pairs are not great hands to call down, but they work well as semi-bluffs.
- ♦ Big gutshots such as KJ can be called most of the time. The weaker KT and JT play a mixed strategy, sometimes calling and sometimes folding. Wheel gutshots that can make an A-5 straight can be x/r some of the time when they have a BDFD but are mostly folded when they don't.
- ♦ King-high no draw and all the rest of the air makes up 48% of BB's range and is simply folded every time.

Flop Strategy Example 2

BB vs Min-bet: BB vs UTG on Q♥J♥T♥ (40bb)

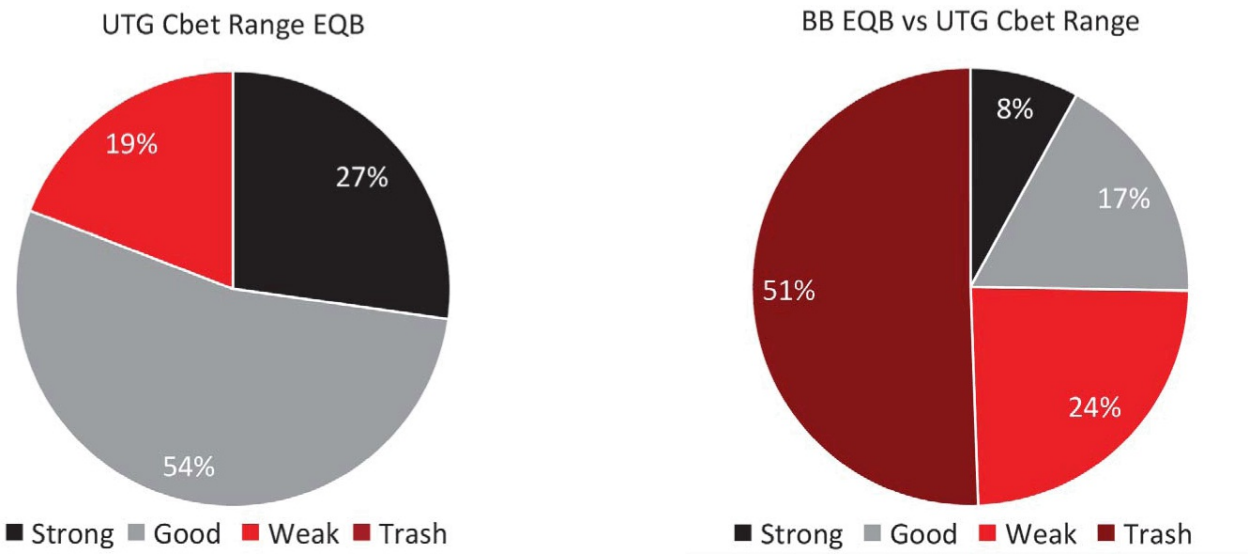


Diagram 101: BB vs Min-bet: BB vs UTG on Q♥J♥T♥ (40bb)

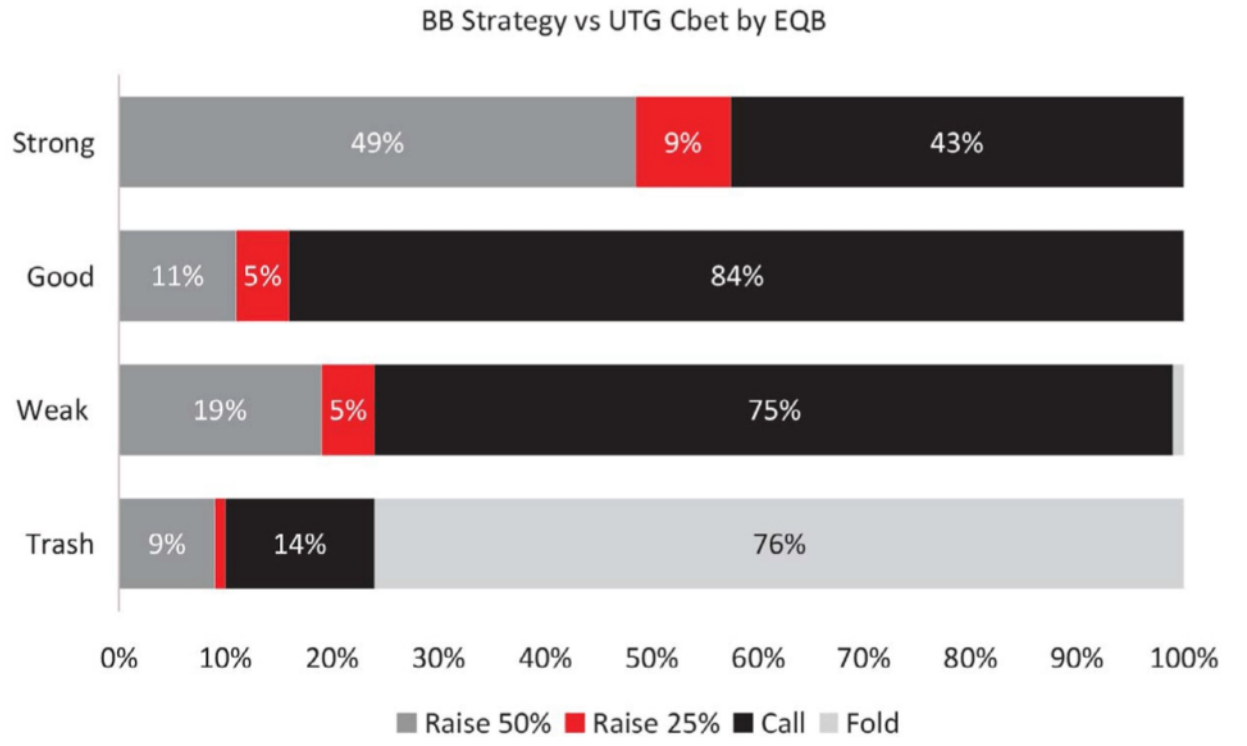


Diagram 102

On QJT monotone, the BB has a substantial equity disadvantage, with only 36% equity. They are also only able to realize 79% of their equity, capturing 28% of the pot and folding, on

average, 38.26% of the time against a flop min-bet, looking to x/r 18% and x/c 43%.

Hand	% of Range	Equity	EV	EQR	Raise 50%	Raise 25%	Call	Fold
Straight Flush	0.3%	99%	306%	308%	1.8%	8.0%	90.2%	0.0%
Flush	7.0%	88%	182%	207%	55.6%	8.9%	35.5%	0.0%
Straight	4.9%	68%	69%	102%	12.9%	6.9%	80.2%	0.0%
Sets	0.6%	65%	92%	140%	18.3%	9.7%	72.0%	0.0%
Two Pair	4.3%	53%	44%	84%	10.8%	6.2%	83.0%	0.0%
Top Pair	8.0%	44%	13%	30%	1.9%	1.2%	95.5%	1.4%
Second Pair	7.7%	38%	5%	14%	4.8%	1.1%	63.0%	31.1%
Third Pair	7.7%	32%	2%	7%	10.6%	1.5%	35.3%	52.6%
Underpair	3.1%	15%	0%	0%	0.0%	0.0%	0.0%	100%
Combo Draw	13.7%	49%	48%	98%	28.0%	6.3%	65.7%	0.0%
Flush Draw	7.6%	32%	8%	25%	28.2%	4.7%	65.6%	1.6%
OESD	11.5%	24%	2%	7%	24.1%	3.2%	29.9%	42.8%
Gutshot	11.3%	16%	0%	0%	0.0%	0.0%	0.0%	100%
Air	12.2%	6%	0%	0%	0.0%	0.0%	0.0%	100%
Full Range	100.0%	36%	28%	79%	15.0%	3.2%	43.4%	38.3%

Table 123: BB Strategy Breakdown vs UTG Min-bet on Q♥J♥T♥

♦ The straight flush makes only a tiny portion of the BB's range but, when having it, the BB's EV is more than 3x the size of the pot! On this flop, if the BB has a straight flush it is very unlikely for UTG to also have a flush as most of the possible hands that could make a flush are blocked by the board and Hero's hand. For this reason, Hero will mostly slowplay the nuts. In the event that IP has an A-high flush or the A♥, the money will go all-in most of the time regardless of how the BB plays their hand, so it makes sense for the BB to let IP do most of the betting.

♦ Flush combos get x/r most of the time. A-high and K-high flushes get x/r about 1/3 of the time, reverse linearly with the highest kickers being x/r less often than the low kicker. For example, A9s never gets x/r, A5s gets x/r 57% and A2s gets x/r about 88% of the time. Lower flush combos are x/r about 88% of the time.

- ♦ Straights are rarely x/r unless they have a flush draw, averaging a x/r frequency of 20%.
- ♦ The BB never has top set. Middle and bottom set are x/r about 22% of the time.
- ♦ Two pair is x/r about 17%.
- ♦ Top pair averages 44% equity on a board as connected as this one with so many flush, straight, set and two pair combinations. Top pair is simply not a strong hand on this texture.
- ♦ Weaker middle pair combos can be x/f most of the time and occasionally x/r. J9 and better can also be x/r with some frequency, and any Jx with a higher kicker plays a 100% call strategy.
- ♦ Weak bottom pairs (T8-T2) are almost always folded. T8 can get x/r a small frequency, and T9 can be x/r half the time. Bottom pair with a higher kicker is always called.
- ♦ Underpairs are always folded unless they have a flush draw.
- ♦ Combo draws are x/r about 1/3 of the time and x/c 2/3. The ones with showdown value such as AT or KJ with a heart are mostly called and the ones without showdown value can be x/r about half the time.
- ♦ On this flop, any high flush draw will either be a made hand or a combo draw. This leaves the flush draw category with mostly weak flush draws such as 76o and 55 type hands. This category gets x/r about 1/3 of the time and called 2/3.
- ♦ OESD will only continue if they are drawing to the nut straight. All 9x except 99 are folded 100%, A8o also gets folded 100%, Kx and A9 without a heart can be x/r about half the time and x/c the other half.
- ♦ All gutshots are folded unless they have a pair.
- ♦ A-high and K-high hands always have at least a gutshot.
- ♦ Air hands such as 7-high no draw are simply always folded.

Flop Strategy Example 3

BB vs 2/3-pot c-bet: BB vs UTG on 9♥8♥4♦ (40bbs)

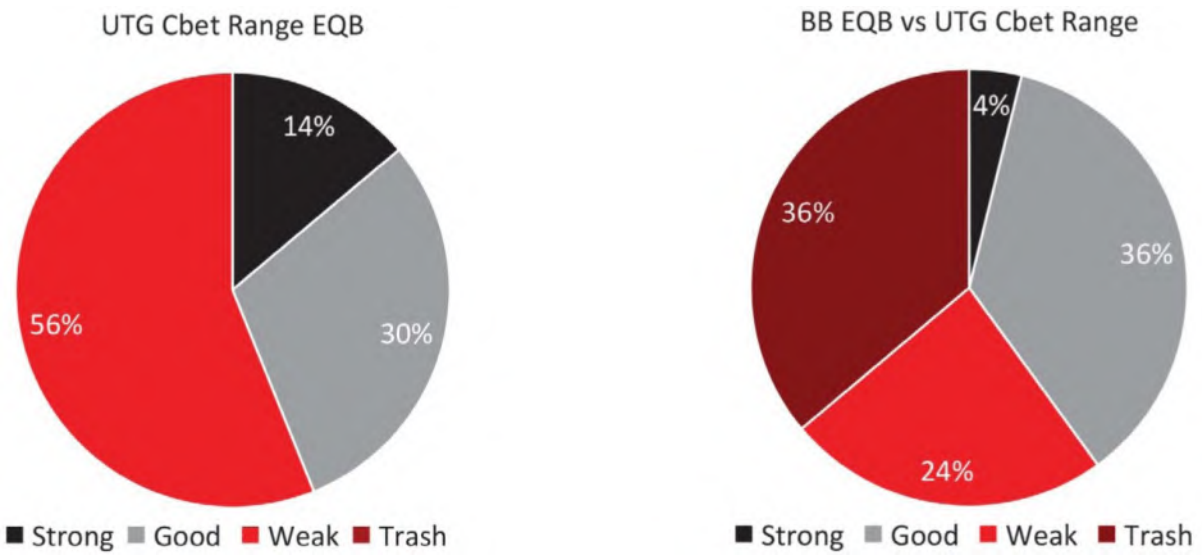


Diagram 103: BB vs 2/3-pot c-bet: BB vs UTG on 9♥8♥4♦ (40bbs)

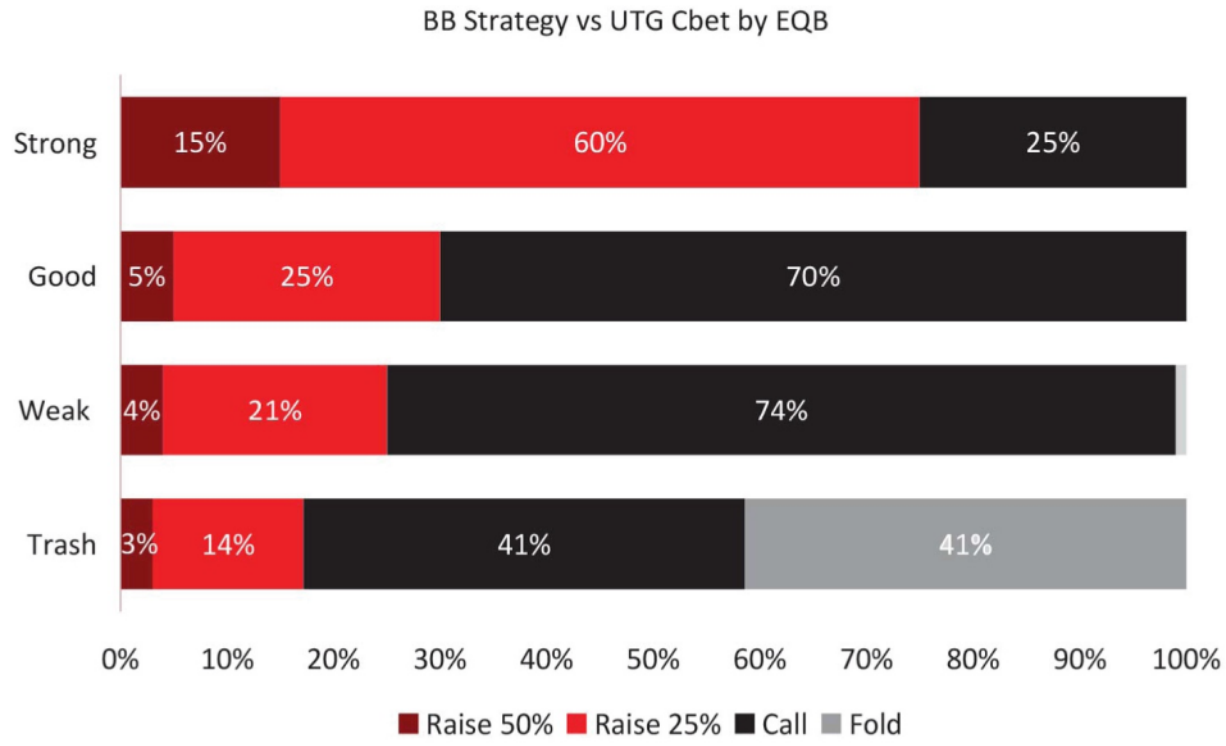


Diagram 104

On 9♥8♥4♦, the BB's range only has about 4% strong hands against UTG. This results in UTG using a large bet-size and the BB having a low x/r frequency of about 4%. The BB's strategy consists of waiting until the turn to start splitting their range, depending on the runout. This avoids revealing information about their range on the flop. If the UTG uses a 1/3-pot c-bet-

size instead, the BB increases their x/r frequency to ~15%. In general, flops with one or more possible flopped straights are better for the BB, and flops without flop straights tend lower their EV.

Hand	% of Range	Equity	EV	EQR	Raise 50%	Raise 25%	Call	Fold
Sets	1.6%	89%	322%	361%	0.6%	11.2%	88.2%	0.0%
Two Pair	2.2%	81%	233%	288%	0.6%	17.5%	81.9%	0.0%
Over Pair	1.1%	61%	58%	94%	27.2%	46.2%	26.7%	0.0%
Top Pair	12.6%	58%	37%	64%	0.4%	2.1%	97.4%	0.0%
Second Pair	11.2%	54%	25%	45%	0.3%	1.2%	98.4%	0.0%
Pocket 2-3 (77-55)	3.2%	47%	0.1%	0.2%	0.1%	3.2%	12.5%	84.2%
Third Pair	6.9%	49%	8%	16%	1.1%	2.2%	96.8%	0.0%
Combo Draw	1.5%	55%	112%	204%	9.5%	22.9%	67.6%	0.0%
Flush Draw	7.4%	53%	78%	148%	3.9%	6.5%	89.6%	0.0%
OESD	5.7%	40%	40%	100%	0.0%	0.0%	100.0%	0.0%
Gutshot	9.4%	29%	4%	14%	0.3%	5.0%	54.1%	40.6%
Ace-high	12.7%	37%	1%	3%	0.2%	1.1%	15.7%	83.0%
King-high	11.2%	23%	0%	0%	1.4%	0.0%	4.2%	94.5%
Air	11.2%	17%	0%	0%	0.0%	0.0%	0.0%	100%
Full Range	100%	42%	29%	70%	0.9%	3.2%	54.8%	41.1%

Table 124: BB Strategy Breakdown vs UTG 2/3-pot c-bet on 9♥8♥4♦

♦ Sets are only x/r about 12% of the time, with 99-88 being almost always called, and 44 only getting x/r when it has a heart. The reason for this is that IP has the bigger sets so having a heart gives the BB a little extra equity in the case of running into a cooler situation. The idea of the BB having to x/r this flop every time they have a strong hand because of the possible straight and flush draws is unfounded as these draws only make up about 10.5% of UTG's range. In this case, the lack of strong combos in the BB's range and keeping their information advantage is more important for the BB than "protecting" the hand. In this situation, the BB compensates for the lack of flop aggression with an aggressive turn donking strategy on favorable runouts.

- ♦ Two pair are x/r about 18% of the time, with 98 and 84 being x/r more frequently than 94. Typically, the solver shows a slight preference to x/c top and bottom two pair when compared to top two and bottom two. Top two are the most nutted ones, so it makes sense to x/r them more frequently, and bottom two pair needs more protection and unblocks top pair, while top and bottom blocks top pair in the Villain's range.

- ♦ Overpairs JJ-TT are the most x/r hands, as they have good equity but are vulnerable. JJ is x/r 100% and TT mostly x/r when having the T♥.

- ♦ Top, middle pair and bottom always get x/c. 77-55 are almost always folded except for 77 with a heart.

- ♦ Combo draws are x/r 1/3 of the time and x/c 2/3 of the time. Q♥J♥ and Q♥T♥ are x/r 100%. J♥T♥ and J♥7♥ are x/r about 1/3 and lower combo draws are mostly x/c.

- ♦ Flush draws are only x/r about 10% of the time. The most frequently x/r combos are ATs-A5s ~60%

- ♦ OESD are x/c every time. These combos have good equity vs IP's c-bet range but are too weak against IP's flop 3-betting range as they will often be dominated by overpairs or flush draws.

- ♦ Gutshots with two overcards or a BDFD are called, the rest get folded.

- ♦ A-high is mostly folded, except AJ+ plus BDFD that gets called about 40%.

- ♦ K-high is mostly folded except for a few KQ with the K♥ that occasionally gets called.

- ♦ Air is folded 100% of the time.

Flop Strategy Example 4

BB vs Minbet: BB vs BN on J♠6♥6♦ (40bbs)

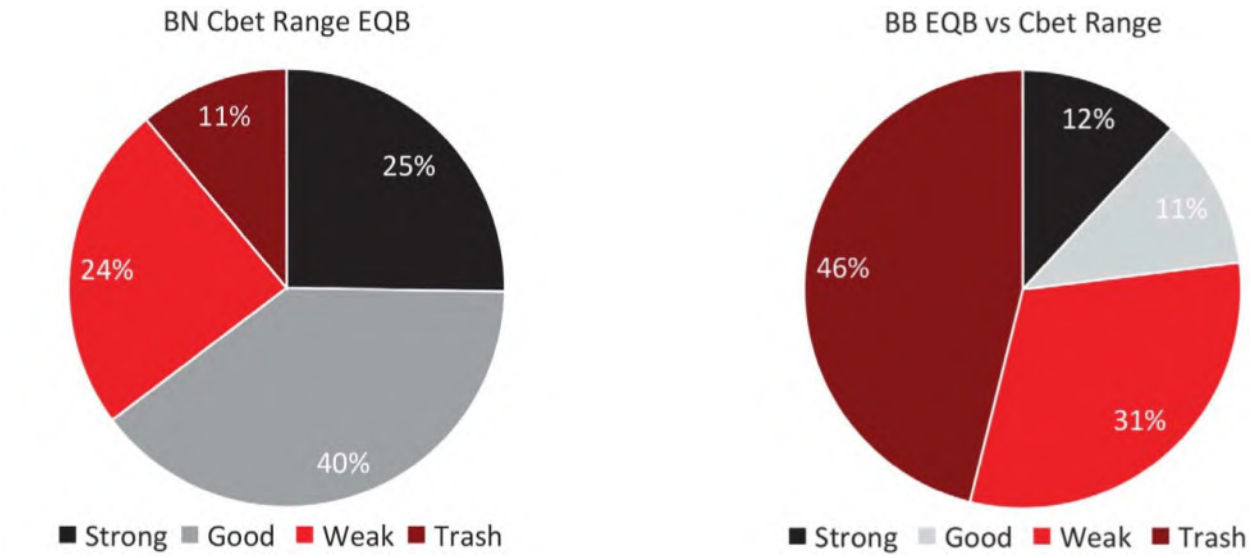


Diagram 105: BB vs Minbet: BB vs BN on J♠6♥6♦ (40bbs)

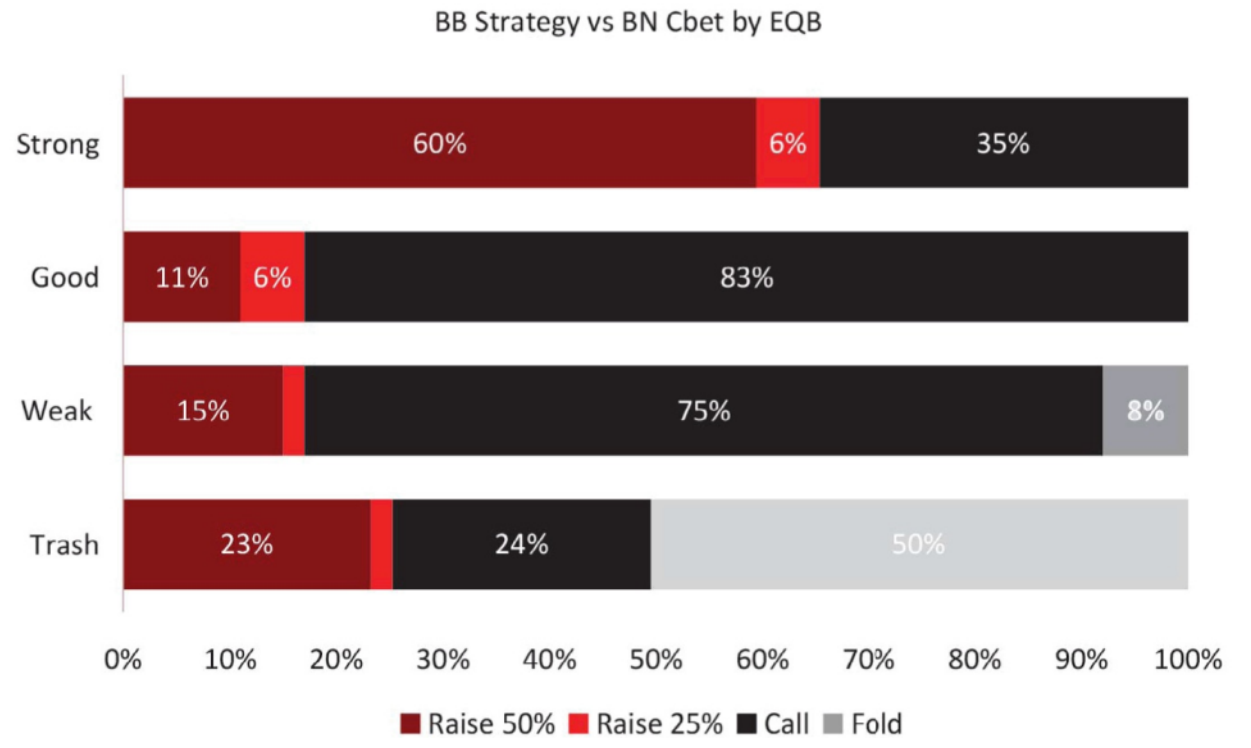


Diagram 106

On J♠6♥6♦, the BB's range gets heavily polarized with a reasonable amount of strong hands that connect trip sixes. This results in the BB having a healthy x/r range of about 27%, using mostly the bigger x/r size.

Hand	% of Range	Equity	EV	EQR	Raise 50%	Raise 25%	Call	Fold
Full House	0.9%	98%	291%	296%	1%	2.7%	96.3%	0.0%
Trips	8.9%	93%	237%	254%	75%	5.3%	19.4%	0.0%
Top Pair	11.3%	74%	85%	116%	16%	7.2%	76.6%	0.0%
Under Pair	1.4%	46%	24%	62%	1%	3.2%	96.2%	0.0%
A-high	13.2%	48%	14%	30%	3%	2.9%	94.2%	0.0%
K-high	17.8%	37%	4%	12%	33%	1.8%	65.0%	0.0%
Air	46.5%	24%	1%	6%	25%	2.1%	24.0%	49.3%
Full Range	100%	42%	37%	88%	24%	3.0%	47.8%	25.4%

Table 125: BB Strategy Breakdown vs BN Min-bet on J♠6♥6♦

♦ The BB never has quads as they would always 3-bet 66 pre-flop.

♦ Full houses are rarely x/r. J6 does not need any protection and it blocks IP's top pair combos.

♦ Trips are x/r reverse linearly 80% of the time and x/c 20%. Trips with high kicker work better as x/c because they block IP's overcards and overpairs.

♦ Top pairs with high and middle kickers are often x/r when they have a BDFD and x/c otherwise.

♦ Underpairs 44-22 are always x/c.

♦ A-high hands are always x/c.

♦ K-high, on average, gets x/r about 22% and x/c 65%. K6+ are almost always x/c and K-high with a low kicker mostly gets folded unless it has a BDFD.

♦ Air, Q7+ with a BDFD, gets x/r most of the time and x/c without a BDFD. Q5-Q2 with a BDFD are mostly x/c and sometimes x/r, and combos without a BDFD are mostly folded. The rest of the air combos are x/r most of the time and x/c sometimes when they have a BDFD and a BDSTD and otherwise folded.

GTO TURN STRATEGIES

Given the sheer size of the possible turn strategies on all different lines and runouts it will not be possible to take an approach as exhaustive as we did in the pre-flop and flop sections. However, we will cover the most important concepts that drive GTO play on this street, applying the overall knowledge we have built throughout this book.

Turn play can be extremely challenging for many players, particularly if they are inexperienced. However, in reality, turn play isn't as different from flop play as it may appear.

> *In order to make an educated decision, the main concepts you need to keep in mind are the pot size, the effective stacks, the ranges in play and the board.*

The stacks and pot size are obvious, so we are left with the ranges in play and the board. The ranges in play can be deconstructed from the previous action taken by the players involved in the hand. Assessing the distribution and polarization of the equity of different ranges after a given action line is difficult for many players.

GTO does not care, nor does it take into account, any history from the current or any past hands. It does not care about the betting on the previous round, (x/x) or (x/b/c), or who was the previous aggressor. All a GTO solver needs to compute the equilibrium strategy pair for two players are the ranges in play, the board, the stacks, the pot size and a betting abstraction. The hand history and players' actions leading to the decision point are what we humans need to know so we can have an idea of the ranges in play.

Knowing all the exact ranges for all players in all possible strategic lines by heart is clearly impossible. We cannot compute the GTO strategy for each combo, nor can we memorize solver strategies for every single spot. What we can do is focus our study on some of the key strategic lines and familiarize ourselves with the general morphology of ranges, the equity distributions and how they are affected by the board runout. Every decision point is simply a new puzzle with new pieces. All you have to do is use your knowledge and expertise to put the pieces together and make the best decision possible with the information you have. The only way to get really good at solving that puzzle is through deliberate practice.

Deliberate practice refers to a special type of practice that is purposeful and systematic. While regular practice might include mindless repetitions, deliberate practice requires focused attention and is conducted with the specific goal of improving performance. If you want to know more about deliberate practice, I recommend *Purposeful Practice for Poker* by Dr. Tricia Cardner and Gareth James (dandbpoker.com).

Key Strategy Lines

In the same way as how the ranges in play are different on the flop depending on the pre-flop action, the ranges in play on the turn will be different depending on the previous actions. There are many different flop lines that lead to a turn, but not all of them are equally important. Some lines will happen more frequently than others and will have a bigger impact on your long-term expectation. These are called Key Strategy Lines and, just like when we studied the flop, we do not have to look at every single line leading to a turn in order to understand turn play. We will only focus on some of the key strategy lines to understand turn play.

In this section, we will continue with the Flop Strategy Examples 1, 2, 3 and 4, focusing our study on turn play after the flop action goes x/x and the action goes x/b/c.

Flop Line: IP Checks back (x/x)

- ♦ OOP First Action (x/x/?)
- ♦ IP vs Bet (x/x/b/?)
- ♦ IP vs Check (x/x/x/?)
- ♦ OOP Check vs Bet (x/x/x/b/?)

Flop Line: IP C-bets & OOP Calls (x/b/c)

- ♦ OOP First Action (x/b/c/?)
- ♦ IP vs Donk bet (x/b/c/d/?)
- ♦ IP vs Check (x/b/c/x/?)

♦ OOP Check vs C-bet (x/b/c/x/b/?)

Turn Play After Flop Check Back (x/x)

IP Range

If IP is checking back a GTO strategy, then their range will have the right board coverage and be fairly balanced on most runouts. Still, IP's checking back range will be somewhat capped and a lot more depolarized than their c-betting range as they would have c-bet most of their strong hands on the flop.

OOP Range

If OOP doesn't have a donk betting range, then they have exactly the same range with which they called the pre-flop raise. This means two things. First, this range is very wide compared to IP's range, and second, that this range is still uncapped.

The way the ranges are constructed is somewhat reverse of the flop situation, making OOP's range more polarized than IP's and IP's range more condensed than OOP's. This range distribution generally results in OOP developing a turn betting strategy.

If IP is checking back a non-GTO range, this range will lack the right board coverage and will be heavily capped on many different runouts while being overly represented on others. For example, let's consider the flop strategy Example 3 of 9♥8♥4♥. If IP never checks back hands such as 99 and 88, then OOP's turn strategy on a blank turn such as 2♣ drifts from betting 27% of the time to betting 77% of the time, and IP's EV decreases from 54% of the pot on that specific turn card to 41%. The effect is even greater if IP never checks back a flush draw or any strong hand on the flop. Then if a flush card such as the 5♥ comes, IP's EV decreases to 11%.

You should also be aware when IP checks back a flop that should be c-bet at a high frequency. For example, on AQ3r, if IP checks back they almost always have some sort of made hand and not much air, because people intuitively understand they should c-bet that flop at a high frequency but still struggle to bet hands such as A with a low kicker, KK, Qx, JJ and TT. This strategy is terrible, as it results in IP's range being pretty much face-up, allowing OOP to play accurately against it. Sometimes players will also check back a hand such as AA, trying balance the fact that they are checking back a weak capped range but this doesn't help them as much as they might think. When OOP has an A, there is only one combo of AA left, and this allows OOP to play the Ax very aggressively without having to be too worried about IP having them beat.

This also allows OOP to check/fold quite effectively on the turn if IP decides to make a delayed c-bet.

OOP First Action

Flop	Line	Line Frequency	OOP Range (Combos)	IP Range (Combos)	OOP EQ	IP EQ
AhQd3s	x/x/?	0.8%	579	1.4	30%	70%
QhJhTh	x/x/?	0.1%	570	1	37%	63%
9h8h4d	x/x/?	33.2%	570	65	48%	52%
Js6h6d	x/x/?	33.1%	680	200	44%	56%

Table 126: Turn Decision Point Stats

Checking back almost never happens at equilibrium on A♠Q♦3♠ and Q♥J♥T♥. For this reason, IP's range on the turn contains only 1.4 and 1 combos, respectively. This doesn't mean that there is a single hand IP is checking back, but that they are checking a tiny fraction of the time with a wide variety of hands. This is, as we discussed before, something totally impractical and unnecessary. Even if IP was checking a GTO range in this spot, this line would only happen less than 1% of the time. Still, I wanted to include these flops so we have an idea of how OOP's strategy changes on the four different boards *(Diagram 107)*.

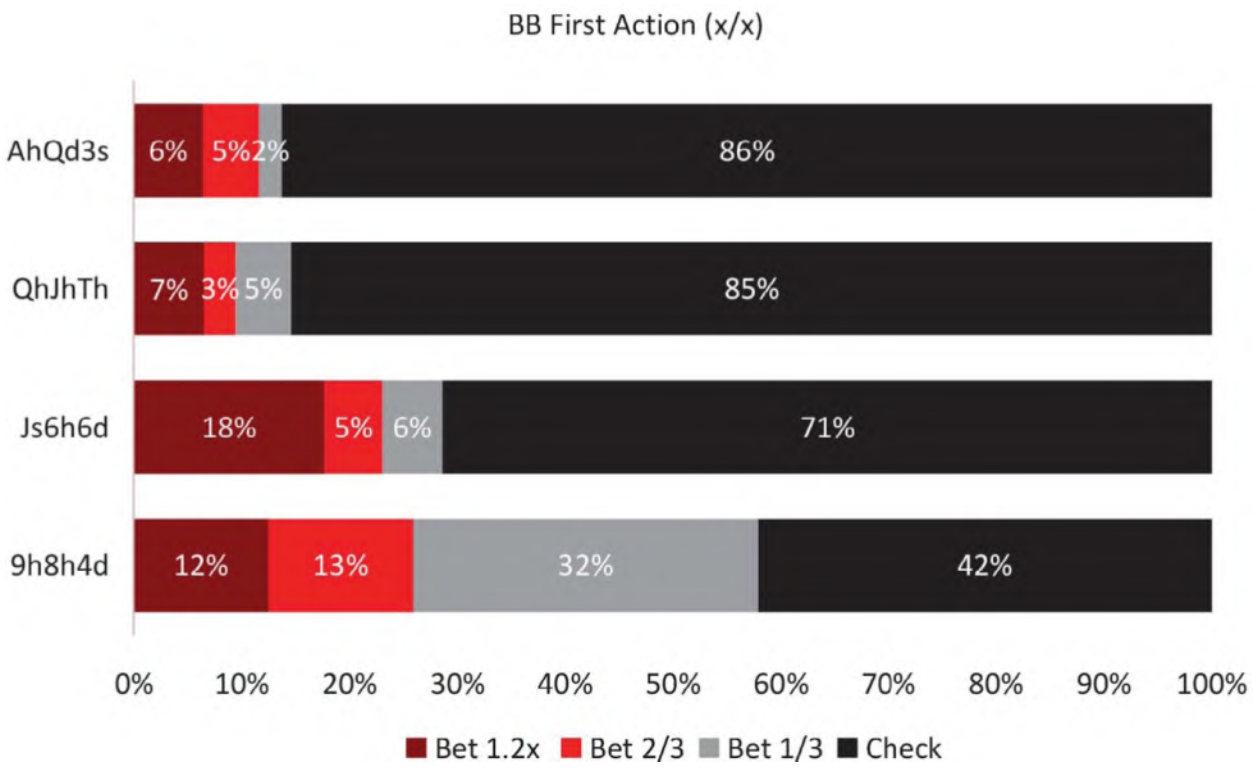


Diagram 107

OOP has three different bet-sizes to choose from: 1.2x-pot, 2/3-pot and 1/3-pot.

As we can see, the average OOP strategy will be different on the turn for the different flop textures. This is again due to the different ranges the players will have on each board, and also because of how the ranges interact with each of the boards.

The OOP strategy when first to act on the turn will also be different within each one of these flops depending on which turn card is dealt.

IP vs Bet

Flop	Line	Line Frequency	OOP Range (Combos)	IP Range (Combos)	OOP EQ	IP EQ
9h8h4d	x/x/b33/?	10.6%	180	65	55%	45%
Js6h6d	x/x/ b120/?	5.8%	125	197	51%	49%

Table 127: Turn Decision Point Stats

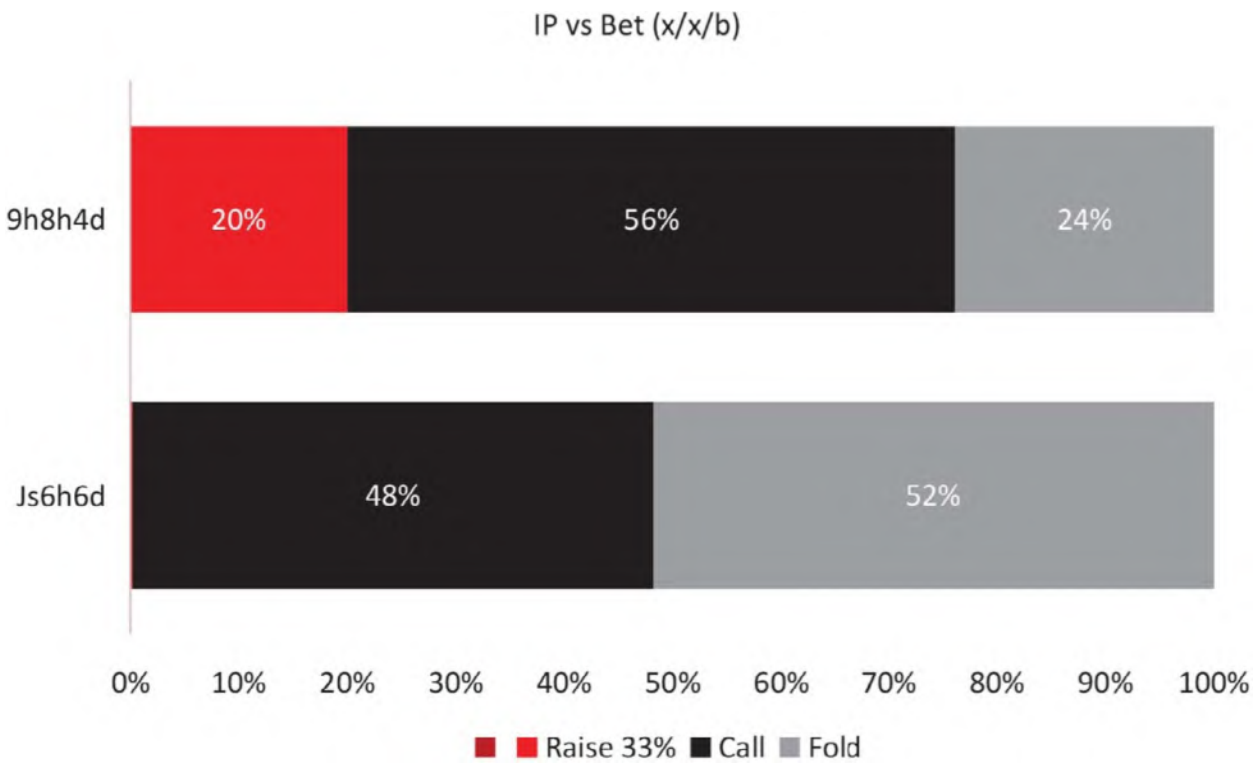


Diagram 108

On 9♥8♥4♦, IP raises a 1/3-pot bet 19% of the time and never raises an OOP overbet on J♠6♥6♦ *(Diagram 108)*. The reason is that, on 9♥8♥4♦, OOP's betting frequency and bet-size are smaller than on J♠6♥6♦ because the polarization of the ranges is different in both cases. On 9♥8♥4♦, OOP's betting range is more condensed and IP has more strong hands, allowing IP to have a raising range. On J♠6♥6♦, OOP's range is more polarized and IP does not have that many strong hands compared to OOP.

IP vs Check

Flop	Line	Line Frequency	OOP Range (Combos)	IP Range (Combos)	OOP EQ	IP EQ
9h8h4d	x/x/x/?	14%	126	65	41%	59%
Js6h6d	x/x/x/?	23.6%	472	197	41%	59%

Table 128: Turn Decision Point Stats

This line happens frequently, overall 14% of the time on 9♥8♥4♦ and 24% on J♠6♥6♦.

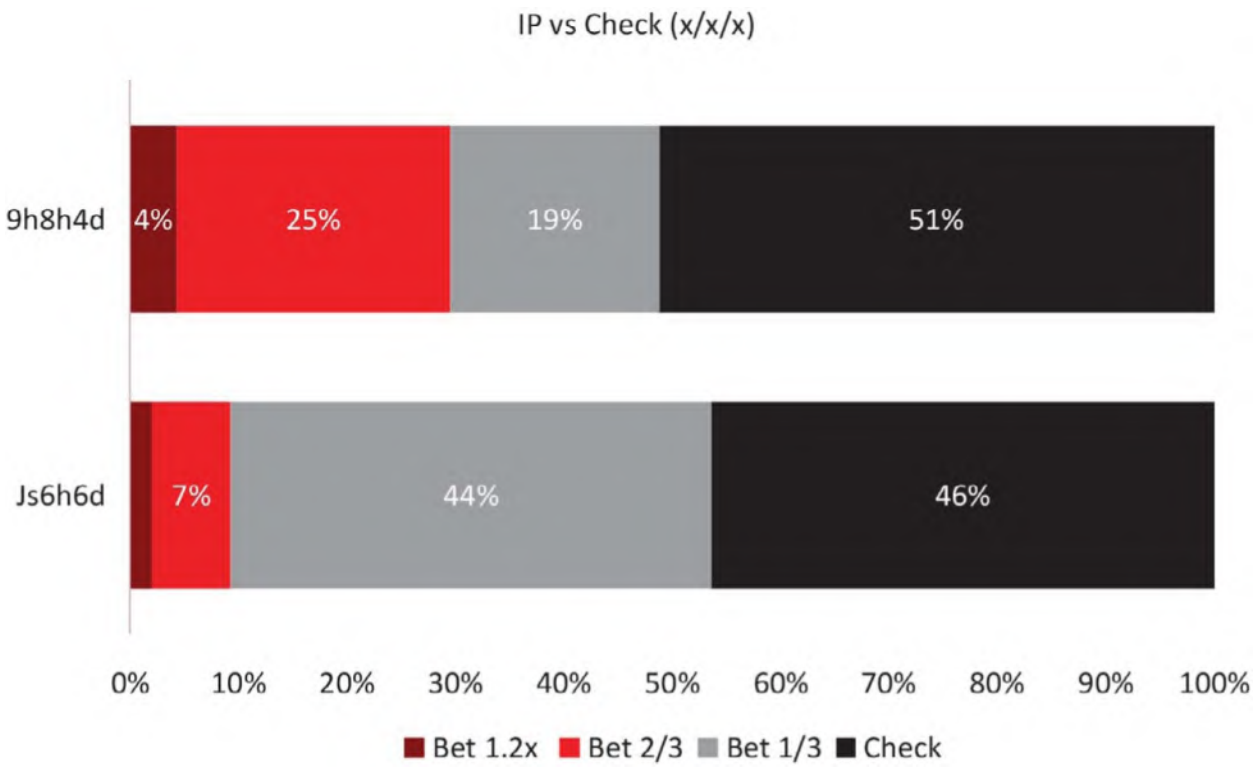


Diagram 109

On the average turn on 9♥8♥4♦, IP likes to bet 2/3-pot because OOP should not have too many strong hands after checking twice on a board as dynamic as this one, because most of their strong hands would bet at some point earlier.

On J♠6♥6♦, IP mostly uses the 1/3-pot bet as this board is quite static. Most hands that were strong on the flop will still be quite strong on the turn and the river, so OOP can afford to slowplay and trap them without risking being outdrawn as often. Also, most hands that were weak or trash on the flop won't have improved on the turn and won't improve too much on the river. So, OOP is forced to play more passively on the turn, checking most of their range. In this situation, OOP's range will remain fairly polarized, so IP can take a stab at the pot using a small bet-size and expect to get many folds *(Diagram 109)*.

OOP vs Bet

Flop	Line	Line Frequency	OOP Range (Combos)	IP Range (Combos)	OOP EQ	IP EQ
9h8h4d	x/x/x/b67/?	3.5%	126	14.4	37%	63%
Js6h6d	x/x/x/b33/?	10.4%	472	89	39%	61%

Table 129: Turn Decision Point Stats

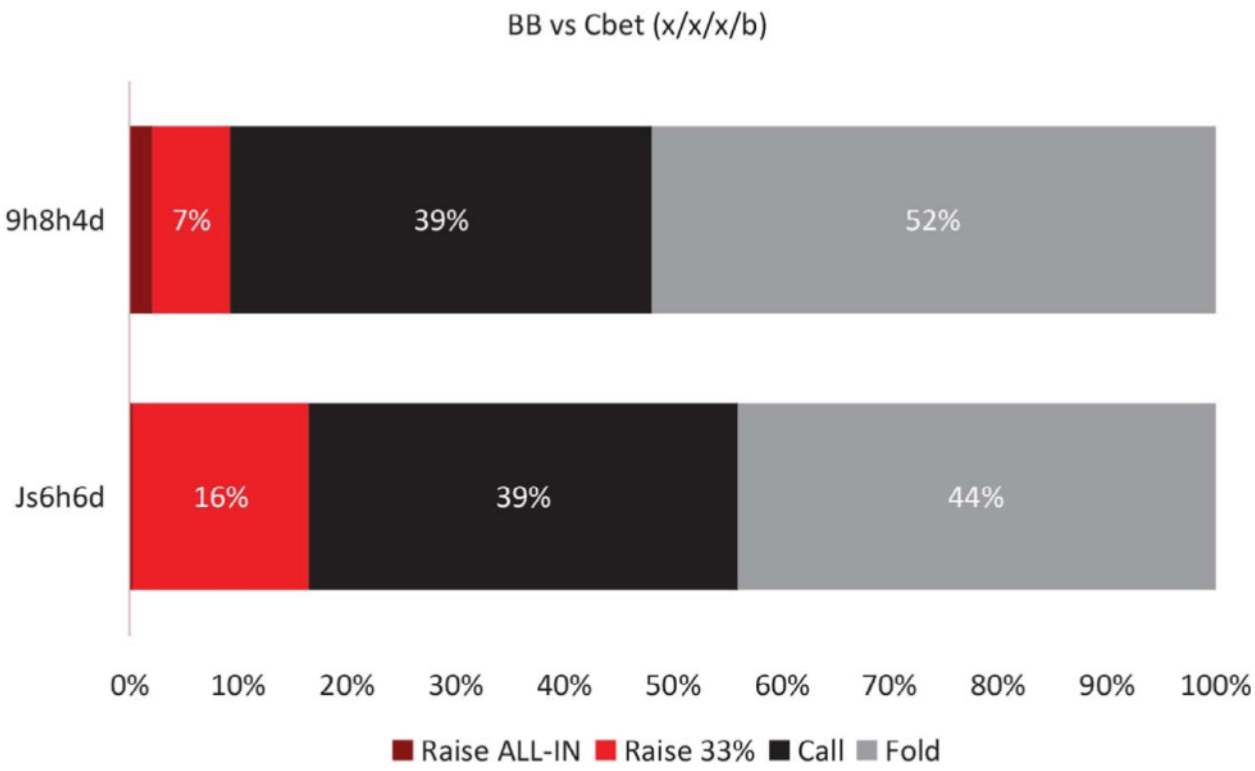


Diagram 110

OOP folds slightly more to the IP stab on 9♥8♥4♦ because IP's bet-size is bigger, making it more difficult for OOP's weak hands to continue. Also, OOP x/r the flop more on J♠6♥6♦ because their range is more polarized, and also because IP's bet-size is smaller. If IP overbets the pot instead, then OOP would only x/r about 3% hands on J♠6♥6♦ *(Diagram 110)*.

Turn Play After Flop C-bet and Call (x/b/c)

In general, IP will c-bet most strong and trash hands on the flop, making their flop c-betting range more polarized. At the same time OOP will fold most trash and raise some of strong hands

against the flop c-bet. This makes OOP's range more condensed coming to the turn after the action goes x/b/c.

OOP First Action

Flop	Line	Line Frequency	OOP Range (Combos)	IP Range (Combos)	OOP EQ	IP EQ
AhQd3s	x/b/c/?	24.5%	147	170	53%	47%
QhJhTh	x/b/c/?	43.7%	258	175	48%	52%
9h8h4d	x/b/c/?	36.0%	306	131	52%	48%
Js6h6d	x/b/c/?	33.7%	345	405	47%	53%

Table 130: Turn Decision Point Stats

Equities run much closer after the flop goes x/c, but the overall polarization will, in general, be in favor of the previous street's aggressor and the caller will tend to have the most condensed range.

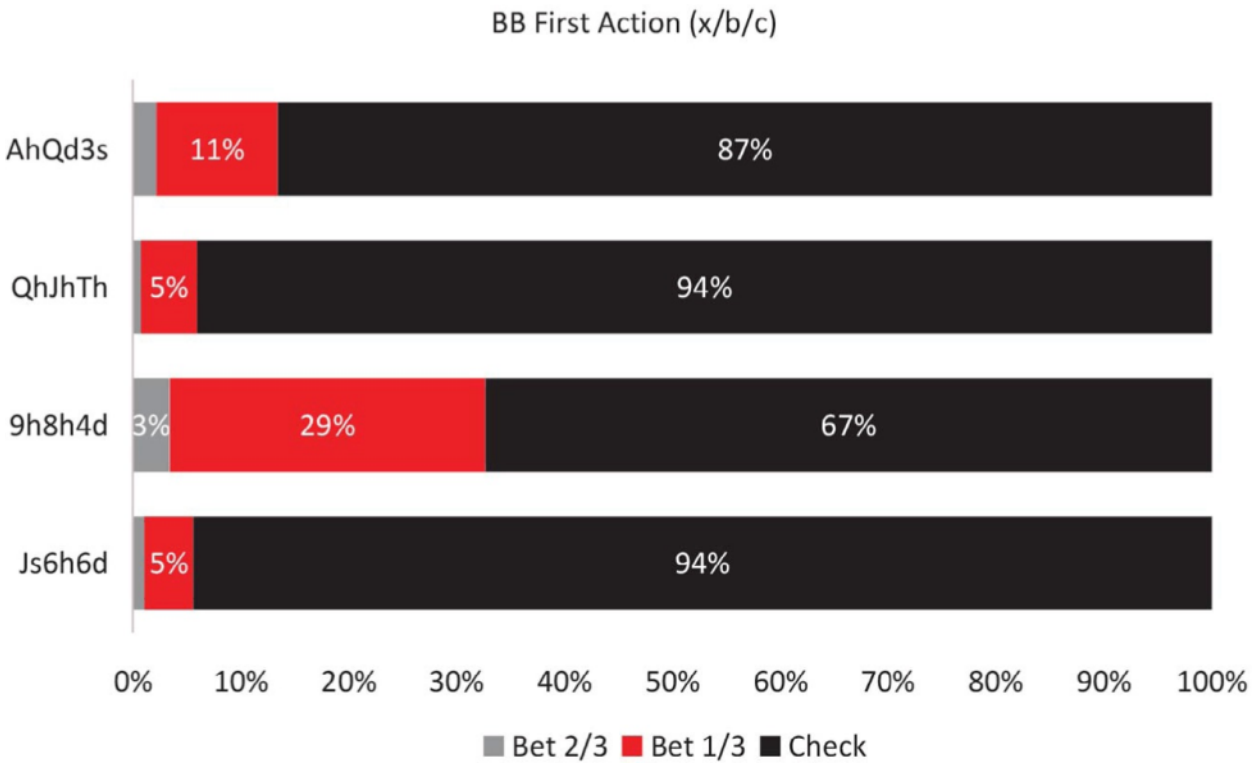


Diagram 111

Since OOP's range will typically be more depolarized than IP's, we see a general trend from OOP to check to IP *(Diagram 111)*. However, similarly to the flop donk bet, there will be some turns that will make OOP's range more polarized and IP's more condensed, resulting in an increased OOP betting frequency.

The solver typically likes to use small bet-sizes when donk betting the flop compared to betting the turn after a x/x flop. This is because of the difference of the polarization of the ranges in both cases.

IP vs Donk Bet

Flop	Line	Line Frequency	OOP Range (Combos)	IP Range (Combos)	OOP EQ	IP EQ
AhQd3s	x/b/c/d33/?	2.8%	31	170	57%	43%
QhJhTh	x/b/c/d33/?	2.3%	5	175	57%	43%
9h8h4d	x/b/c/d33/?	10.5%	192	131	54%	46%
Js6h6d	x/b/c/d33/?	1.5%	6	398	55%	45%

Table 131: Turn Decision Point Stats

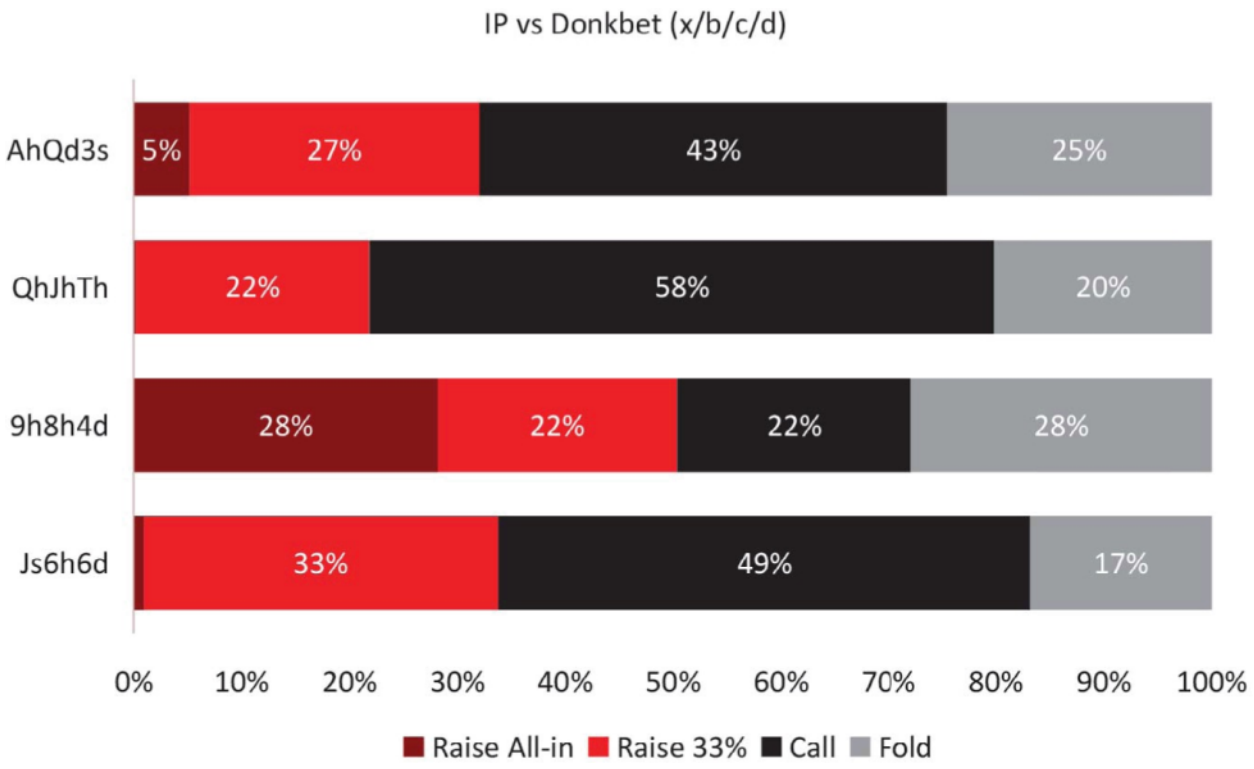


Diagram 112

Since turn donk bets aren't as common as on the flop, this line happens rarely. Because in most situations IP has position and an uncapped range, they won't be folding a lot vs the donk bet and, instead, will be raising at a high frequency *(Diagram 112)*.

Even in modern games, people still fail to donk bet the flop as often as they could and many players will simply auto-check the turn without giving much thought about how it affects the ranges.

IP vs Check

Flop	Line	Line Frequency	OOP Range (Combos)	IP Range (Combos)	OOP EQ	IP EQ
AhQd3s	x/b/c/x/?	21.3%	115	170	52%	48%
QhJhTh	x/b/c/x/?	41.1%	250	175	47%	53%
9h8h4d	x/b/c/x/?	24.2%	10	131	50%	50%
Js6h6d	x/b/c/x/?	31.8%	332	398	47%	53%

Table 132: Turn Decision Point Stats

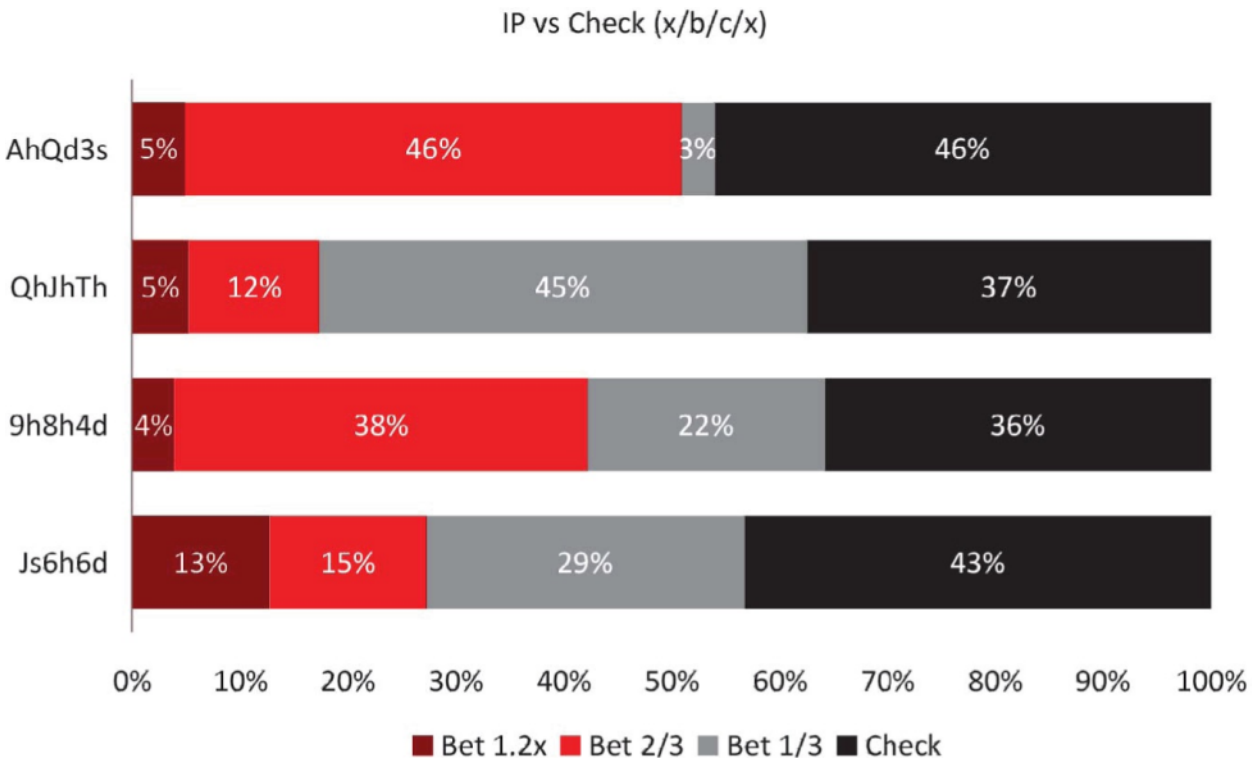


Diagram 113

This line happens frequently, probably even more so in real games as most people fail to donk bet the flop nearly as much as the GTO solver recommends. In general, after the flop goes x/b/c and OOP checks one more time on the turn, IP's range will be very polarized and OOP's range will be mostly condensed. This effect gets magnified on some turn cards that give way more strong hands to IP than to OOP, resulting in IP preferring bigger bet-sizes, and in some cases even overbets *(Diagram 113)*.

On A♥Q♦3♠, OOP's range will still be capped on most turn cards. For this reason, we see IP continue to bet 2/3-pot with the intention to jam the river at a high frequency.

OOP vs Turn C-bet

Flop	Line	Line Frequency	OOP Range (Combos)	IP Range (Combos)	OOP EQ	IP EQ
AhQd3s	x/b/c/x/b67/?	9.8%	115	65	43%	57%
QhJhTh	x/b/c/x/b33/?	18.6%	250	73	44%	56%
9h8h4d	x/b/c/x/b67/?	9.3%	110	62	45%	55%
Js6h6d	x/b/c/x/b33/?	9.4%	332	130	45%	55%

Table 133: Turn Decision Point Stats

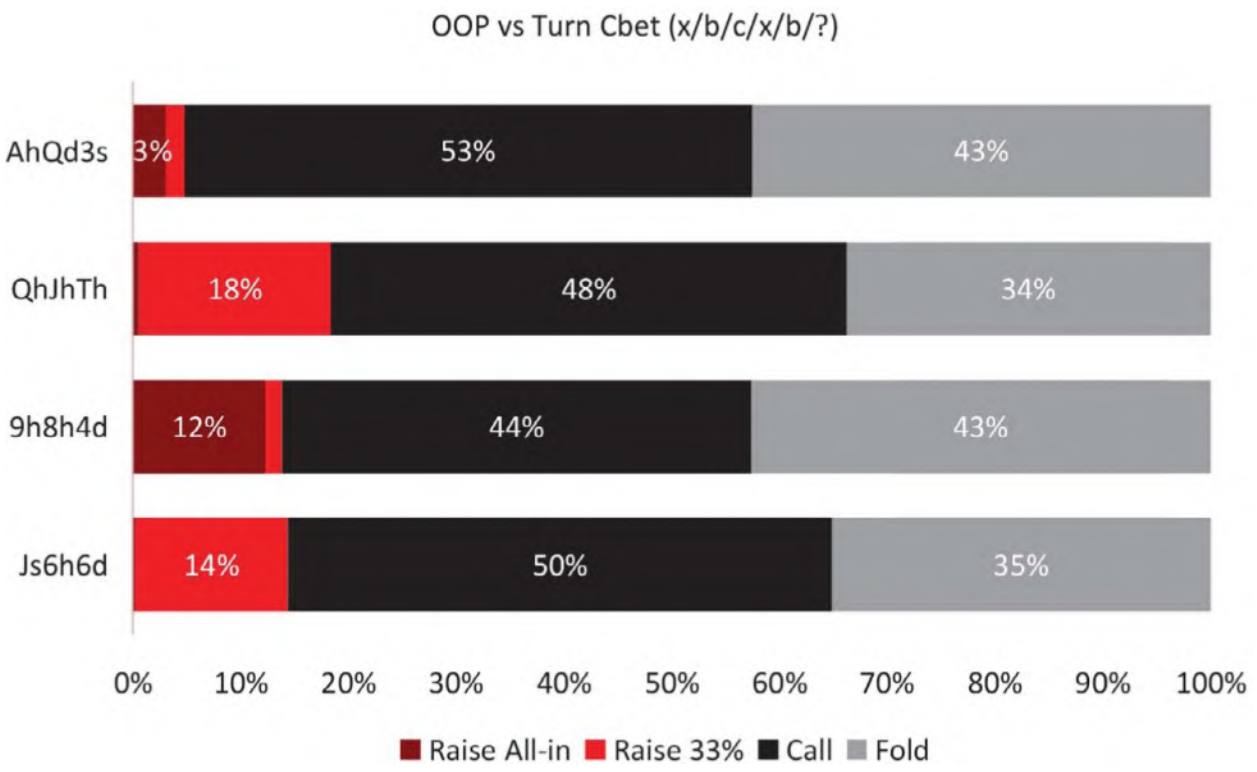


Diagram 114

Facing a second barrel puts OOP in a tough spot. At this point, OOP will have a reasonable equity disadvantage, their range will be very depolarized and IP's range will be even more polarized than it was on the flop *(Diagram 114)*.

Turn Categories

There are 49 possible turn cards for every single flop, and each turn will impact the ranges in play in some way. This will consequently affect the players' GTO strategies. In this sense, turn play is not so different to flop play where players have to be mindful of the way the board runout affects the equity distributions, while at the same time being aware of the possibility of a new card coming and impacting equities again on a later street.

Studying each individual turn for every single flop would also be highly inefficient. For this reason, we will need some sort of turn groupings in a similar way to how we previously created the flop groupings.

Most turn cards can be categorized as being in one or more of the following groups:

♦ **Paired Board:** Turn cards that pair the board.

♦ **Flush:** Turn cards that complete a flush.

♦ **Straight:** Turn cards that complete an OESD.

♦ **Ace:** The ace is a special card and it often has a significant effect.

♦ **Overcard:** Turn cards higher than top pair.

♦ **Brick/Blank:** Turn card that doesn't connect with the board in a meaningful way.

The overcard and undercard categories can be subdivided into cards that bring a backdoor flush draw and cards that don't.

Flop Strategy 1: Turn Play after Flop Checks Back (x/x)

OOP First Action: BB vs UTG on 9♥8♥4♦ (40bb)

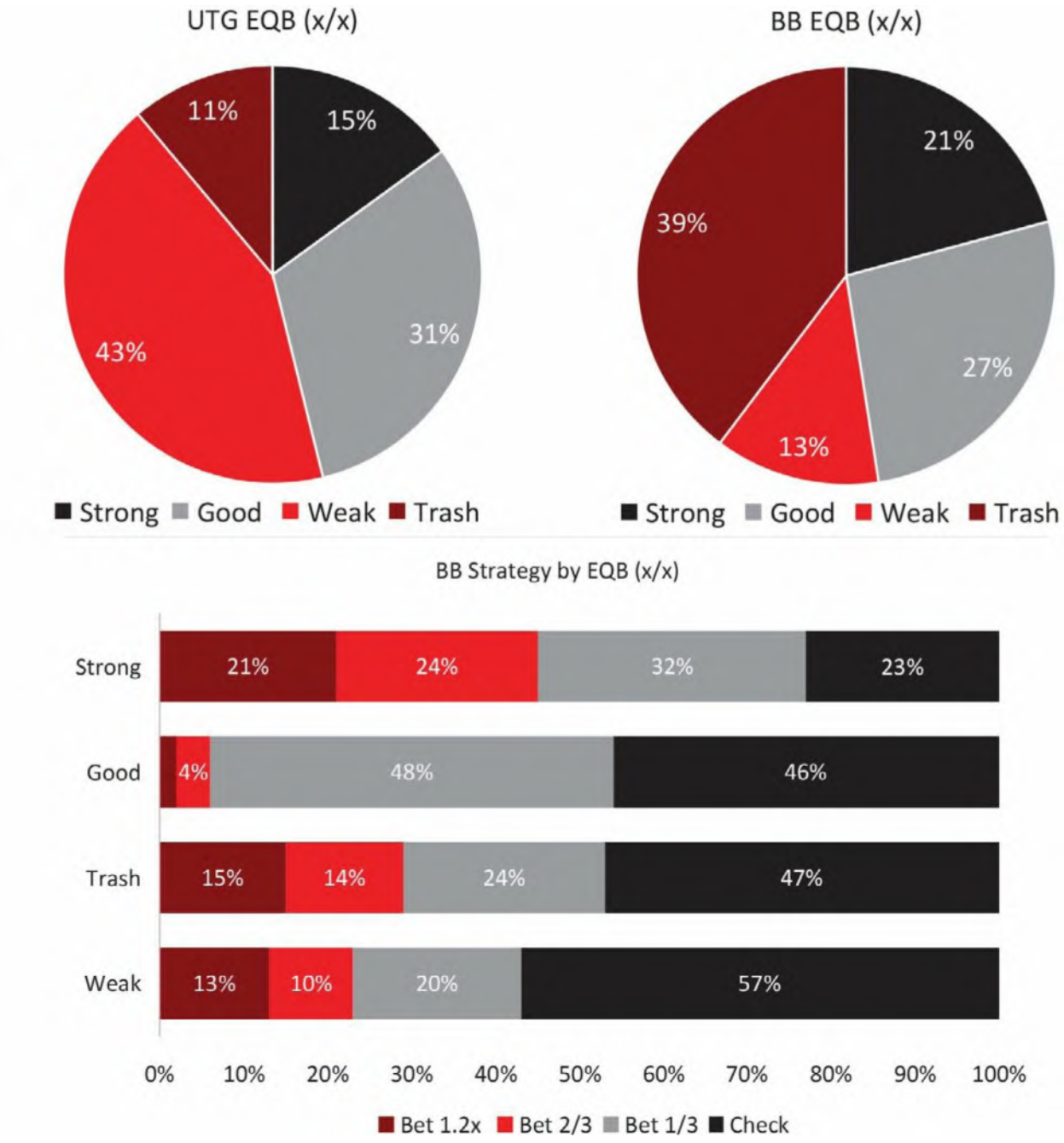


Diagram 115

On 9♥8♥4♦, OOP has the polarization advantage on many turn cards, resulting in a high betting frequency *(Diagram 115)*.

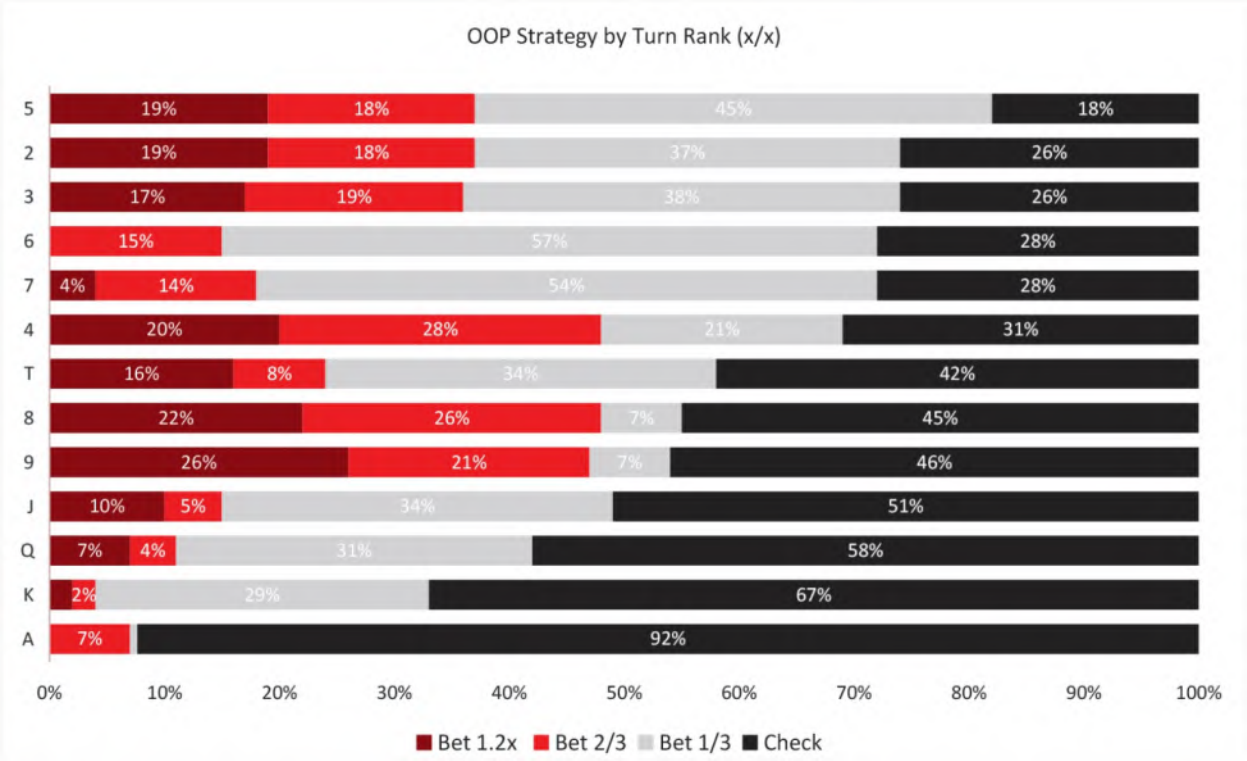


Diagram 116

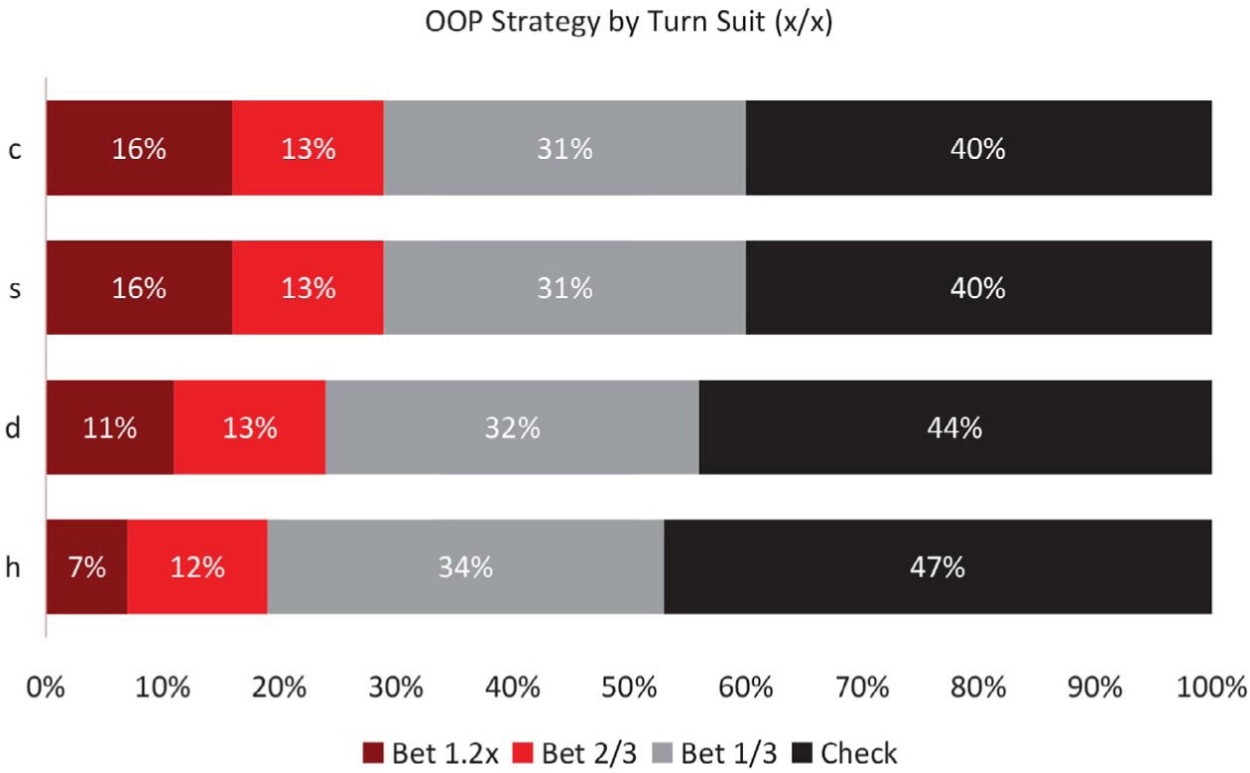


Diagram 117

In general, low cards that complete straights, a 9, 8 or 4 pairing the board, and hearts are good turns for OOP *(Diagram 116)*. Overcards to the board that don't complete many straights, and particularly the aces, are good for IP. The effect of the turn card suit is seen in *Diagram 117*.

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	49.1	49.3	45.9	52.7	52.2	52.6	44.7	44.6	50.5	48.3	47.2	45.1	31.5
d	49.0	49.3		52.6	52.1	52.4	45.1	44.9	50.5	48.2	47.2	45.2	32.2
h	51.1	51.4	49.4	54.3	53.7	54.0			52.2	50.5	49.9	47.6	36.9
s	49.1	49.3	45.9	52.7	52.2	52.6	44.7	44.6	50.5	48.3	47.2	45.1	31.5

Table 134: OOP EQ Heatmap by turn card on 9♥8♥4♦ (x/x)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	59.2	59.1	56.0	64.2	58.1	58.2	53.2	54.1	55.9	51.7	50.1	45.1	25.8
d	56.5	56.7		61.3	56.0	55.9	52.3	52.9	54.8	50.3	48.8	44.1	27.5
h	55.8	56.1	55.9	59.9	56.6	56.5			55.7	53.5	53.1	48.8	42.4
s	59.2	59.1	56.0	64.2	58.1	58.2	53.2	54.1	55.9	51.7	50.1	45.1	25.8

Table 135: OOP EV Heatmap by turn card on 9♥8♥4♦ (x/x)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	50.9	50.7	54.1	47.3	47.8	47.4	55.3	55.4	49.5	51.7	52.8	54.9	68.5
d	51.0	50.7		47.4	47.9	47.6	54.9	55.1	49.5	51.9	52.8	54.8	67.9
h	48.9	48.6	50.6	45.8	46.3	46.0			47.8	49.5	50.1	52.4	63.1
s	50.9	50.7	54.1	47.3	47.8	47.4	55.3	55.4	49.5	51.7	52.8	54.9	68.5

Table 136: IP EQ Heatmap by turn card on 9♥8♥4♦ (x/x)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	40.8	40.9	44.0	35.8	41.9	41.8	46.8	45.9	44.1	48.3	49.9	54.9	74.2
d	43.5	43.3		38.7	44.0	44.1	47.7	47.1	45.2	49.7	51.2	55.9	72.5
h	44.2	43.9	44.1	40.1	43.4	43.5			44.3	46.5	46.9	51.2	57.6
s	40.8	40.9	44.0	35.8	41.9	41.8	46.8	45.9	44.1	48.3	49.9	54.9	74.2

Table 137: IP EV Heatmap by turn card on 9♥8♥4♦ (x/x)

OOP does well on the average turn card, with 48% equity, and over-realizes it to win 53% of the pot. The worst possible turn cards for OOP are offsuit aces such as A♠/A♣ where their EV decreases to 25.8%. The best possible turn cards are offsuit 5x such as 5♠/5♣ where their EV increases to 64.17% of the pot. Notice how there is a correlation between OOP's EQ and EV, although the highest EQ card is not necessarily the highest EV card *(Tables 134-137)*.

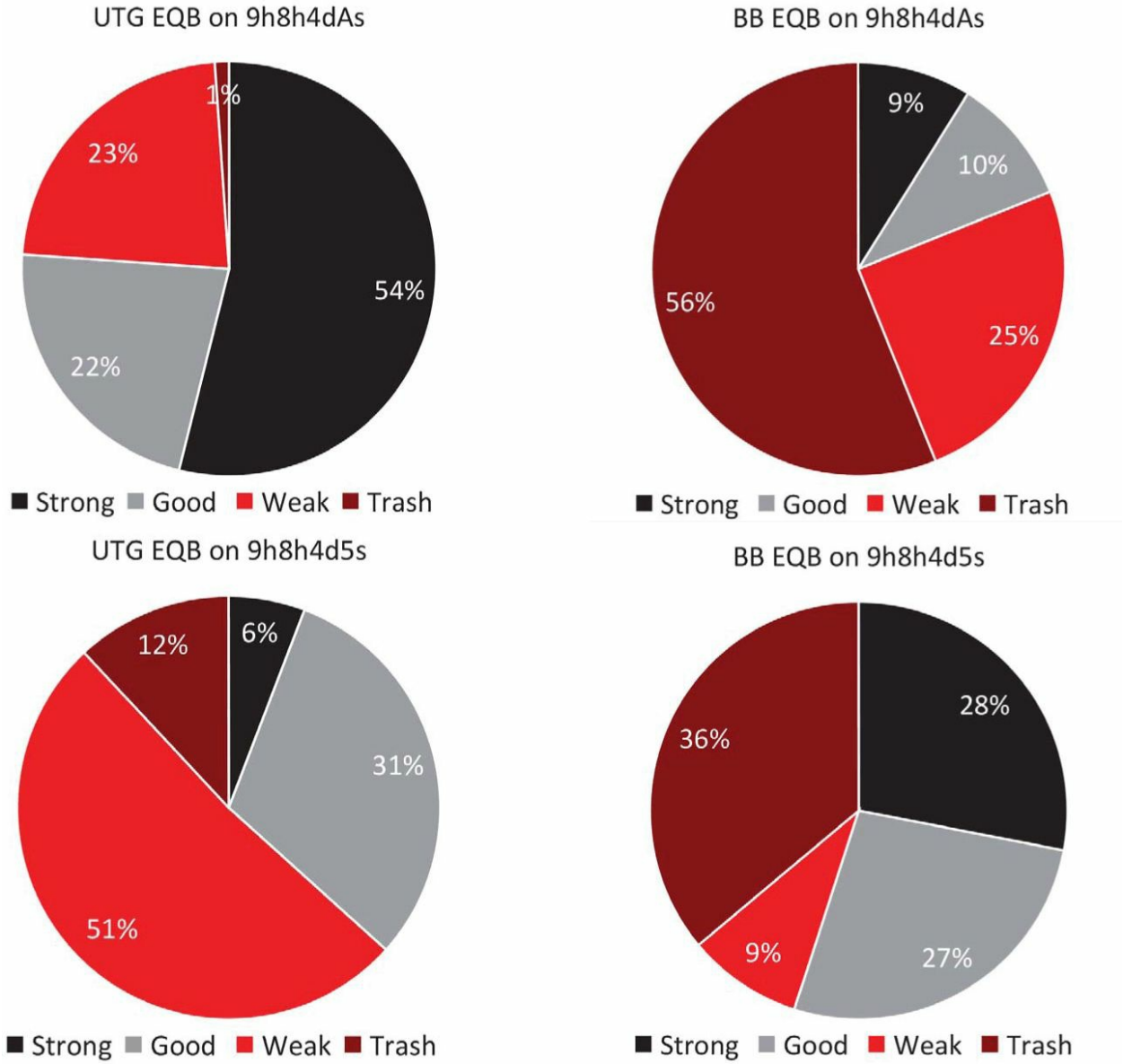


Diagram 118

The EQB charts for the A♠ and the 5♠ turn cards demonstrate just how much range morphology can vary according to the runout, even after the same action line on the same flop *(Diagram 118)*. This has a substantial impact on the players' equilibrium strategies.

Some players struggle to assimilate how a hand that was very strong on a previous street can be demoted and become weaker on a later street. They get emotionally attached to the initial value of their hand and feel entitled to win the pot just because they started with the strongest hand. Nevertheless, this is just all part of the game.

Poker is a game of equities, how much we have, how it is distributed and how we realize it while preventing our opponents from realizing theirs.

On countless occasions I have heard players say something along the lines of, "Every time I have AA, the flush or the straight card comes. I'm so unlucky." You are supposed to have your strong hands demoted sometimes. It can be predicted mathematically and should be expected. So, you should be prepared for the times it happens.

Know your range, as well as your opponent's and understand that, even if on that occasion you might lose a big pot sometimes, you will be the one who has the best of it. The important thing is to play well and adjust correctly to how the situations change. This allows you to prevail in the long run.

Flop Strategy 2: Turn Play after Flop C-bet and Call (x/b/c)

OOP First Action: BB vs UTG on 9♥8♥4♦ (40bb)

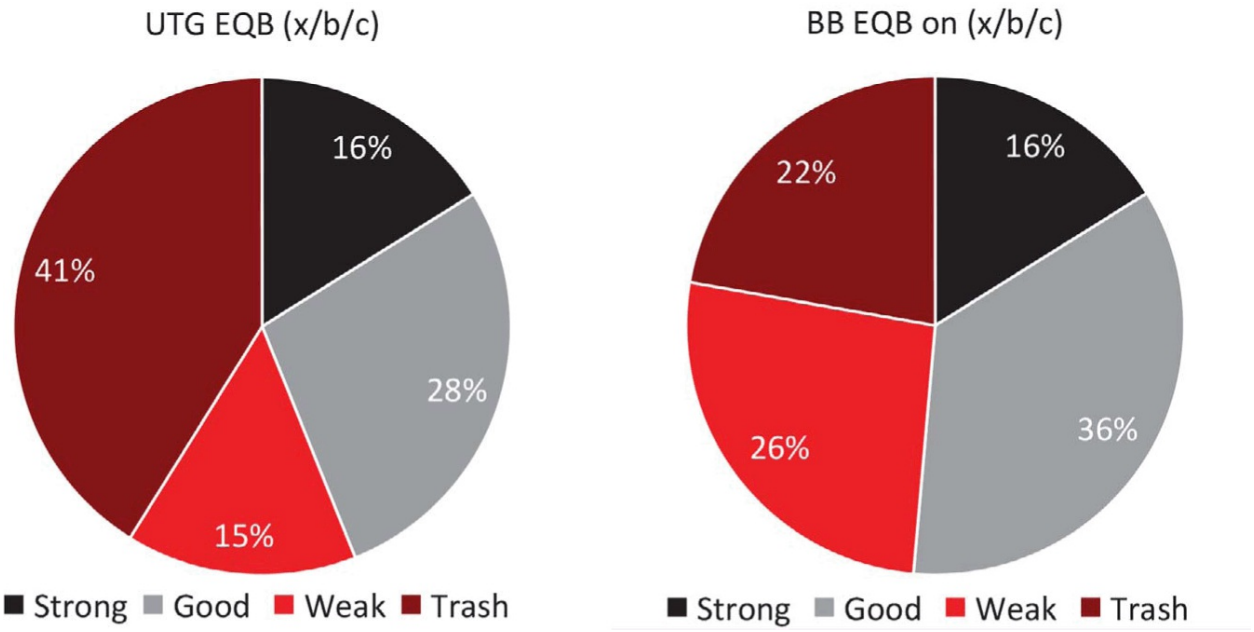


Diagram 119

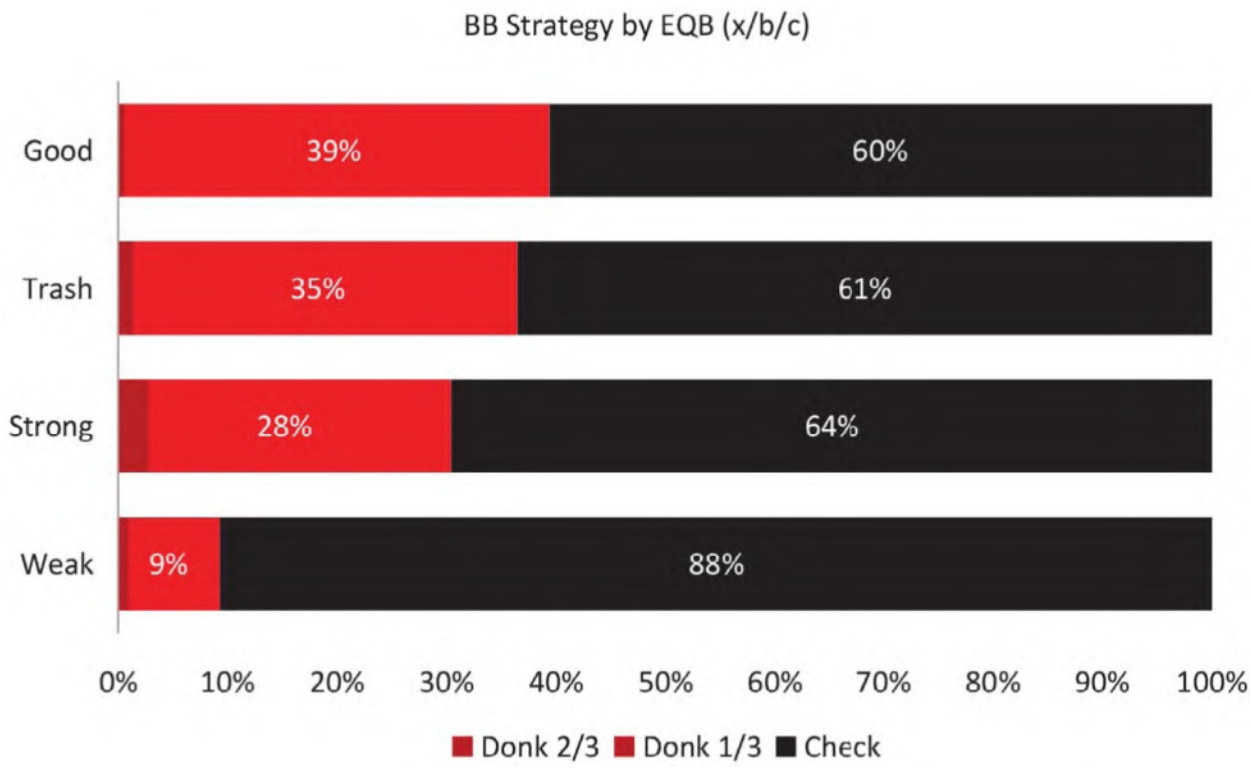


Diagram 120

After OOP x/b/c the flop, both players' equities will run very close on the average turn card *(Diagram 119)*. In fact, OOP has higher EQ (51.65%), but under-realizes it, capturing only 48.6% of the pot, while IP, with 46.6% EQ, captures 51.4% of the pot. Similarly to the flop donk bet, on the turn OOP chooses to donk bet when IP does not have as many dominant strong hands in their range and, instead, has many weaker hands that will benefit from checking back the turn *(Diagram 120)*.

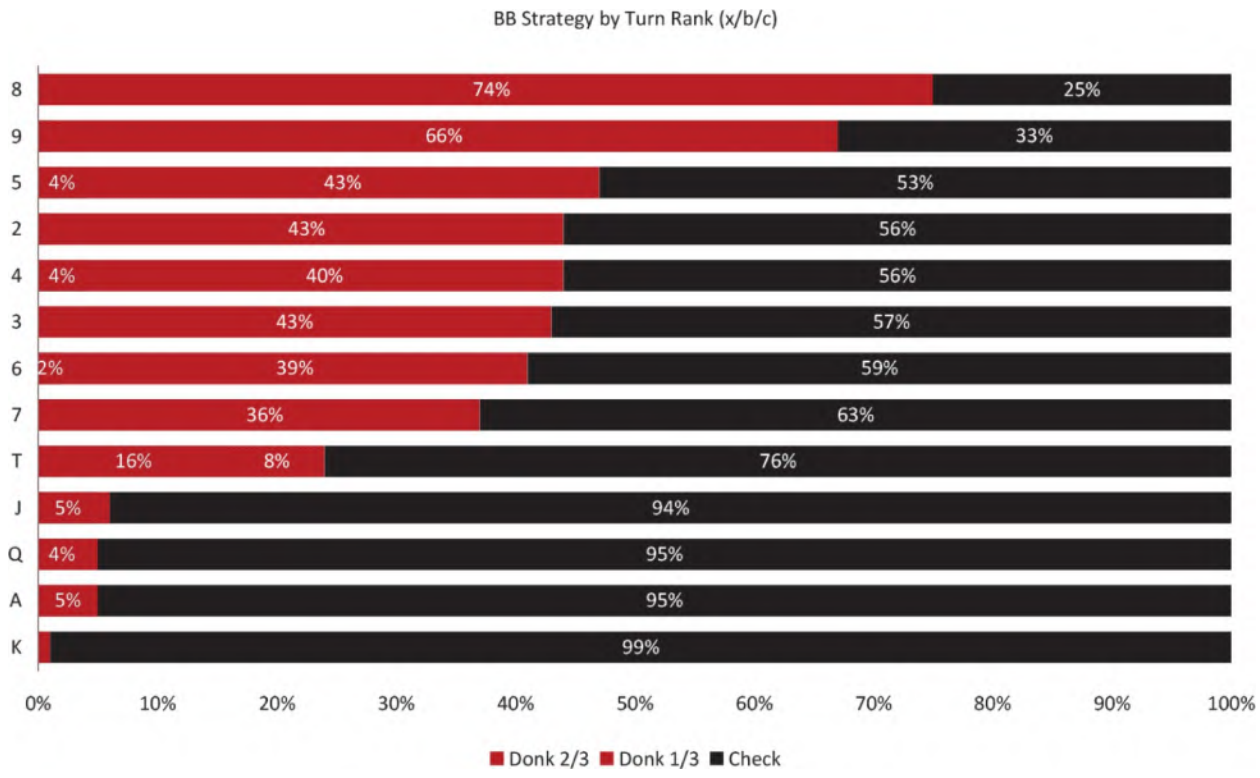


Diagram 121

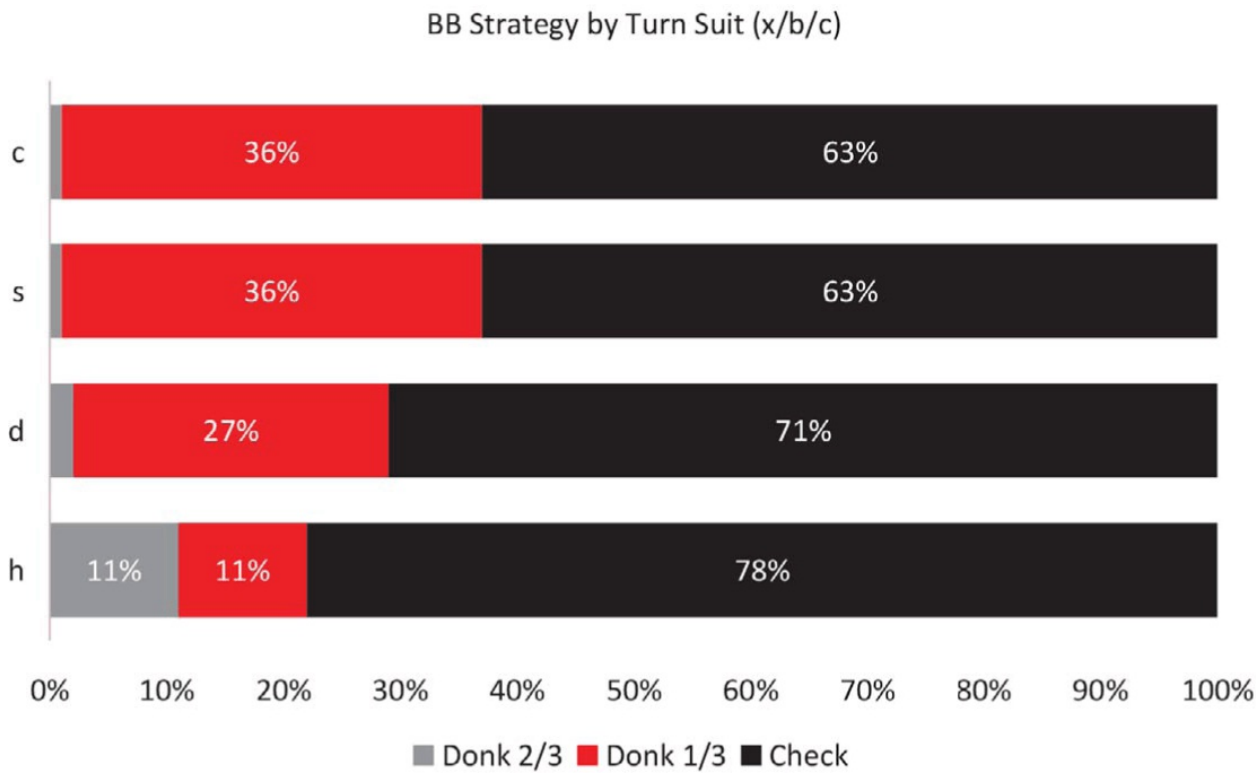


Diagram 122

The best cards for OOP to donk bet the turn are 9, 8 and 4 that pair the board, 7, 6, 5 that complete straights, and blank low offsuit cards. The worst cards to donk bet are the ones that connect well with IP's range, which are aces, high cards, and diamonds that would give the IP player a BDFD *(Diagrams 121-122)*.

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	52.3	52.2	52.2	57.3	56.4	56.4	53.5	52.9	54.0	49.9	48.6	41.9	39.2
d	52.0	52.0		56.7	55.9	56.0	53.2	52.8	53.9	50.0	48.6	42.4	39.4
h	52.2	52.5	54.1	56.9	56.3	56.4			55.7	52.3	50.9	45.4	44.7
s	52.3	52.2	52.2	57.3	56.4	56.4	53.5	52.9	54.0	49.9	48.6	41.9	39.2

Table 138: OOP EQ Heatmap by turn card on 9♥8♥4♦ (x/b/c)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	46.0	45.9	50.8	59.3	54.7	53.8	59.4	57.3	51.1	44.2	42.7	28.7	30.7
d	45.7	45.7		57.9	53.9	53.3	58.5	57.2	51.3	45.1	43.7	31.4	32.1
h	47.3	48.0	52.4	56.2	54.0	53.2			53.6	49.0	47.5	42.2	45.2
s	46.0	45.9	50.8	59.3	54.7	53.8	59.4	57.3	51.1	44.2	42.7	28.7	30.7

Table 139: OOP EV Heatmap by turn card on 9♥8♥4♦ (x/b/c)

Turn Card	2	3	4	5	6	7	8	9	A	J	K	Q	T
c	47.7	47.8	47.8	42.7	43.6	43.6	46.5	47.1	60.8	50.1	58.1	51.5	46.0
d	48.0	48.0		43.3	44.1	44.1	46.8	47.2	60.6	50.0	57.6	51.4	46.1
h	47.8	47.5	45.9	43.1	43.7	43.6			55.3	47.7	54.6	49.1	44.3
s	47.7	47.8	47.8	42.7	43.6	43.6	46.5	47.1	60.8	50.1	58.1	51.5	46.0

Table 140: IP EQ Heatmap by turn card on 9♥8♥4♦ (x/b/c)

Turn Card	2	3	4	5	6	7	8	9	A	J	K	Q	T
c	54.0	54.1	49.2	40.7	45.3	46.2	40.6	42.7	69.3	55.8	71.3	57.3	48.9
d	54.3	54.3		42.1	46.1	46.7	41.5	42.8	67.9	54.9	68.6	56.3	48.7
h	52.8	52.0	47.6	43.8	46.0	46.8			54.8	51.0	57.8	52.5	46.4
s	54.0	54.1	49.2	40.7	45.3	46.2	40.6	42.7	69.3	55.8	71.3	57.3	48.9

Table 141: IP EV Heatmap by turn card on 9♥8♥4♦ (x/b/c)

OOP does pretty well when the turn is a heart and will, on average, have more flush combos than IP. However, OOP doesn't lead them as often because the flushes aren't as nutted as IP's, who will have more nut flushes in their range. The worst cards for OOP are offsuit kings, such as K♣/K♠, and the best cards are offsuit 5s, such as 5♣/5♠ *(Tables 138-141)*.

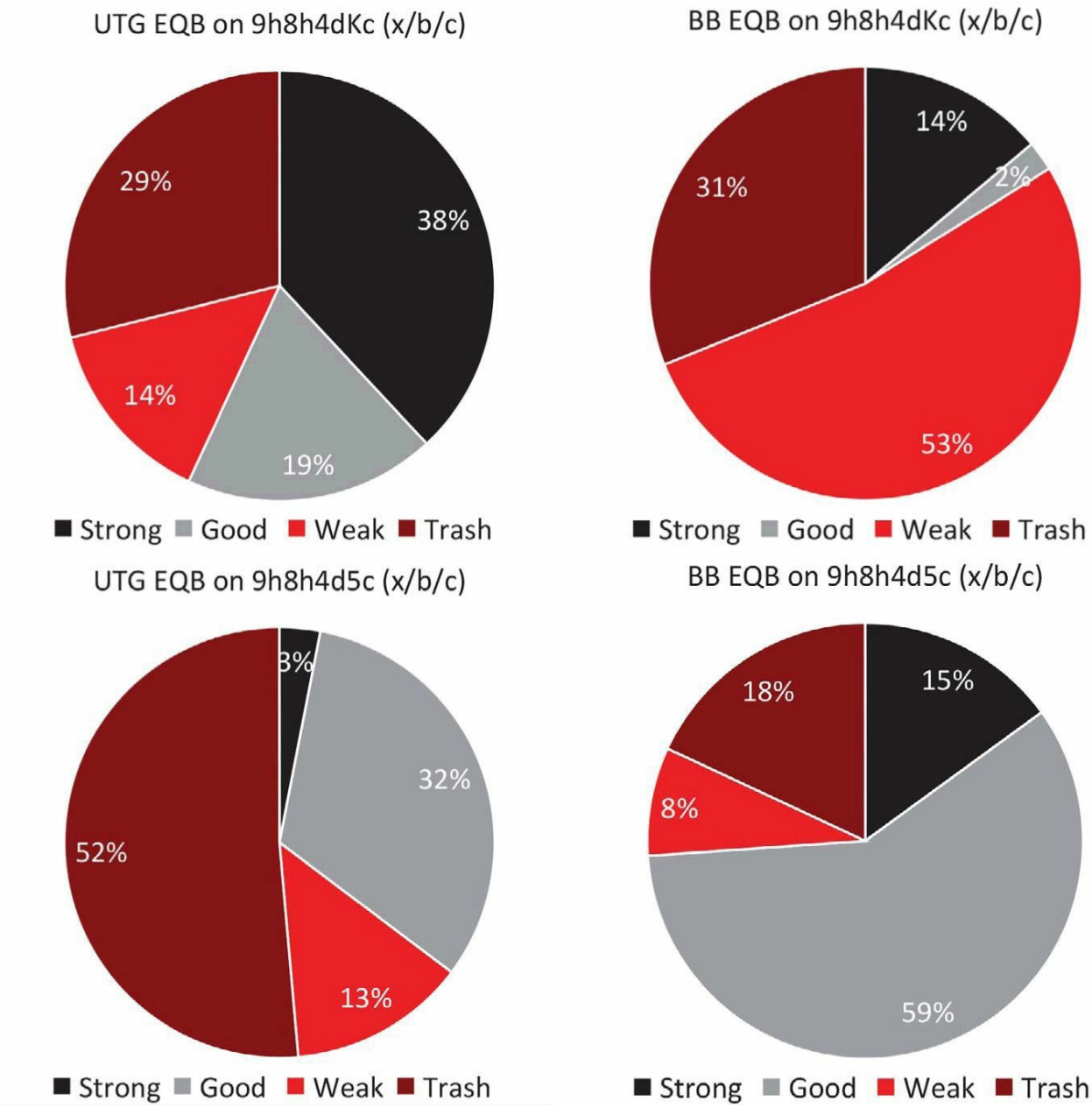


Diagram 123

On a flop as dynamic as 9♥8♥4♦, both players' equity distributions will change drastically

according to the board runout *(Diagram 123)*. This has a significant effect on the players' equilibrium strategies, with OOP wanting to take advantage of the turn cards that give them a massive range advantage by betting aggressively. Naturally, IP will choose to play more passively in these situations.

IP vs Check: BB vs UTG on 9♥8♥4♦ (40bb) (x/b/c/x)

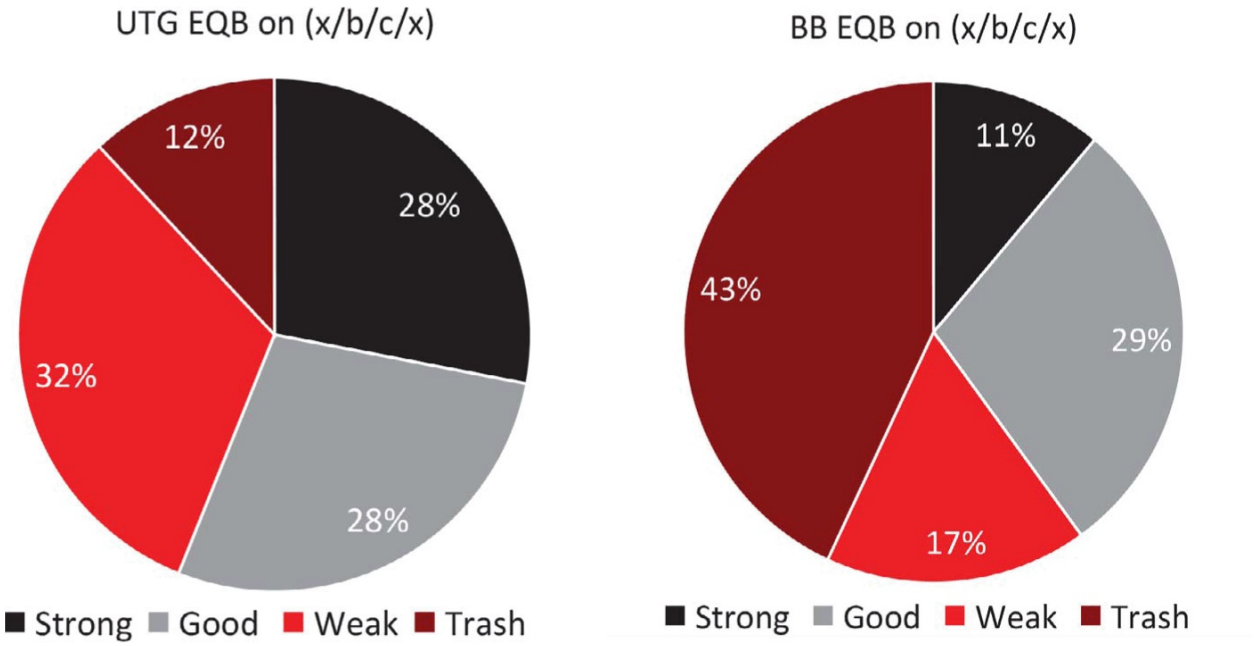


Diagram 124

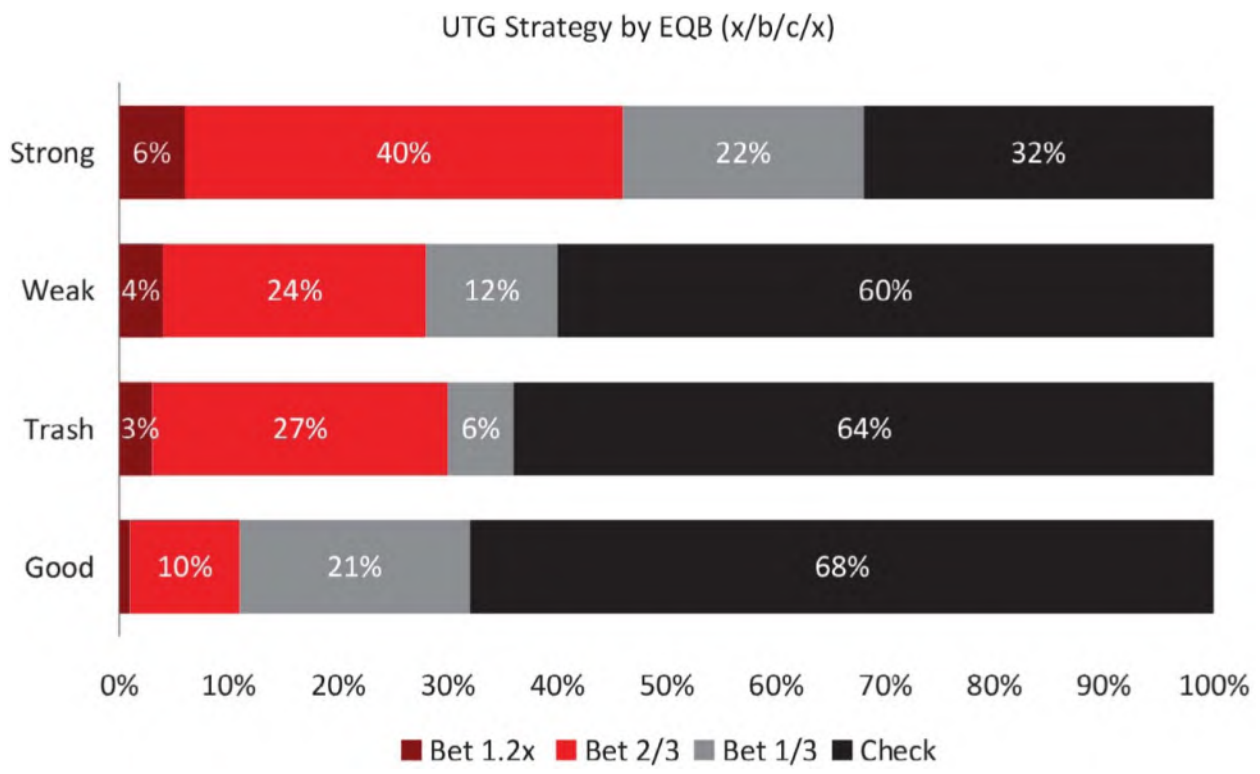


Diagram 125

Typically, the IP player will have a substantial polarization advantage after OOP has checked twice. IP follows a similar trend we already saw on the flop, choosing to split their range. This leads to c-betting once again with most of their strong hands and checking back most of their good hands that don't want to bet/fold and will benefit from seeing a free river. IP will c-bet over 65% of the time and will mostly use a 2/3-pot bet-size *(Diagrams 124-125)*.

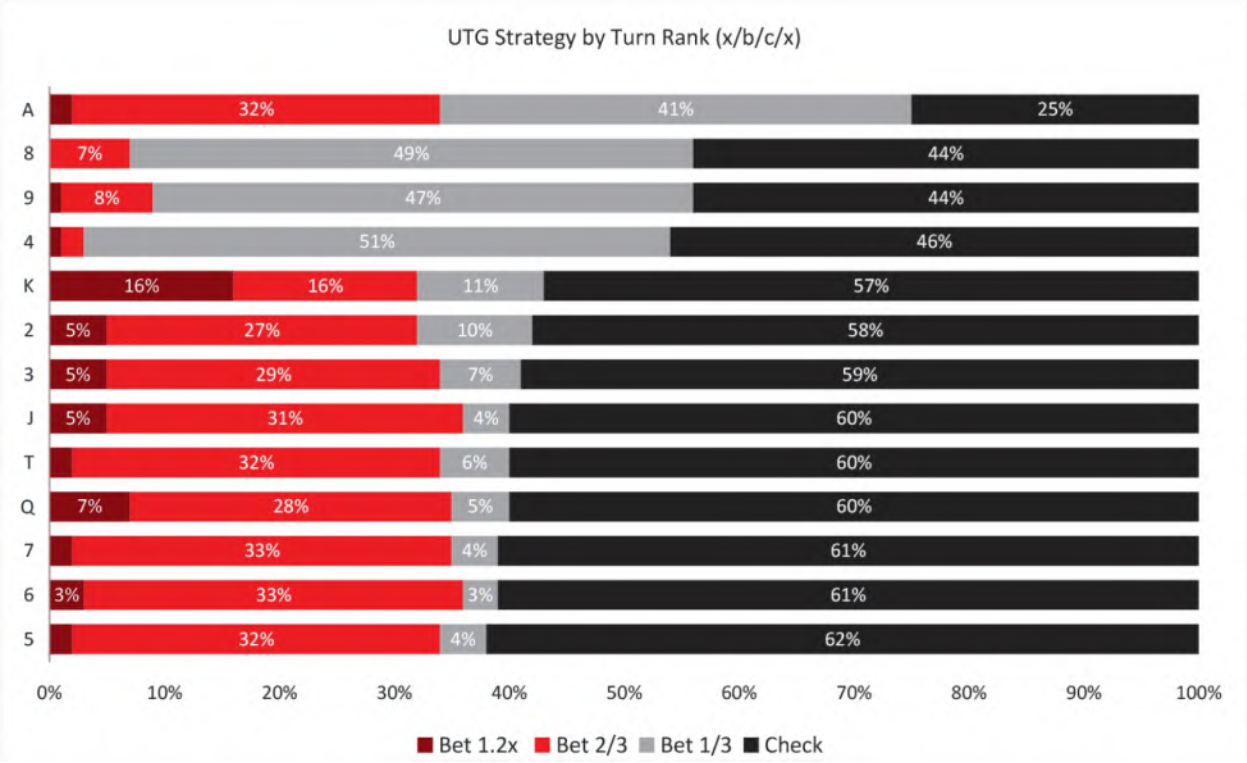


Diagram 126

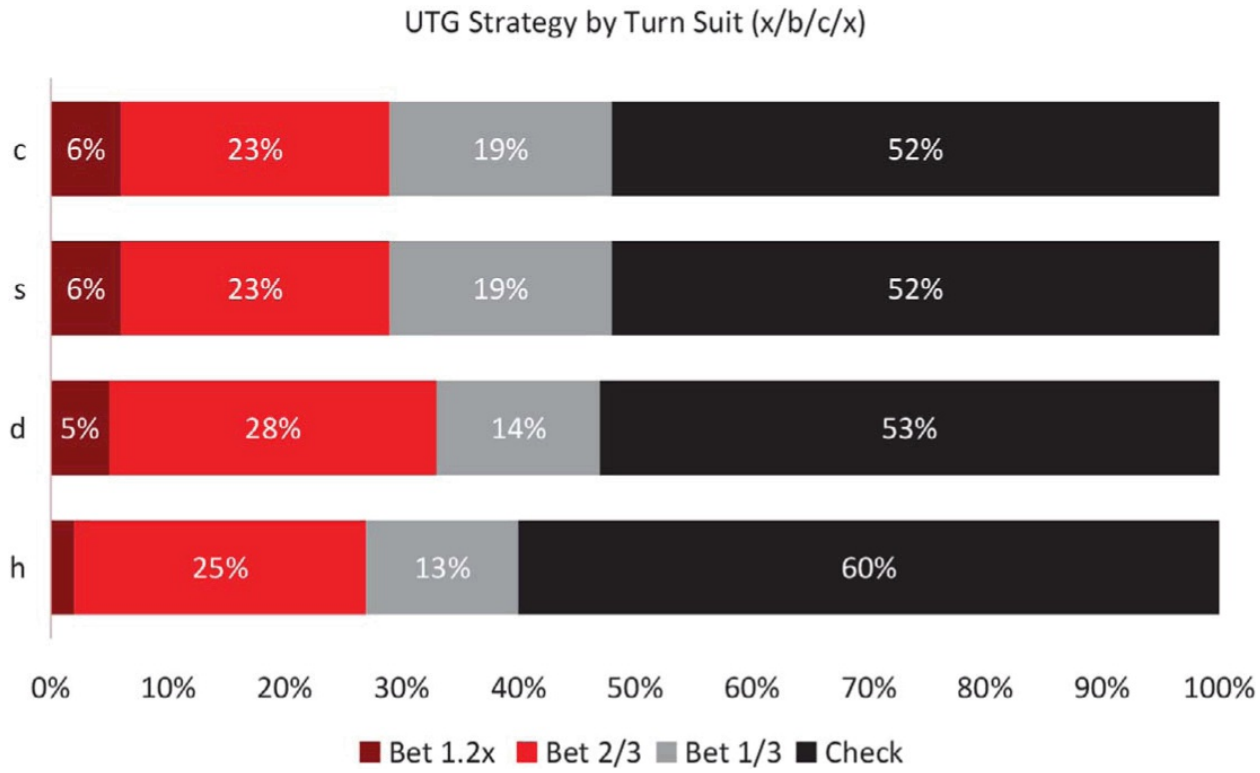


Diagram 127

The 9, 8 and 4 are bad cards for IP, but they still want to bet them at a high frequency when checked to. This happens because IP expects OOP to have a high donk betting frequency on those turn cards, so when they do check, their range will not have as many strong combos. At the same time, there are many hands in OOP's range that will not connect at all with the 9, 8 or 4. So, by betting small, IP can still get many folds. On most other runouts, IP will bet a more polarized range and opt to use a bigger bet-size *(Diagrams 126-127)*.

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	52.4	52.4	52.9	58.4	56.6	55.6	52.8	52.4	53.1	49.9	48.5	41.9	39.1
d	52.0	52.0		57.3	55.9	55.1	52.4	52.2	52.7	49.9	48.6	42.4	39.4
h	52.2	52.4	53.7	55.3	54.9	54.1			51.7	50.8	49.5	45.1	42.4
s	52.4	52.4	52.9	58.4	56.6	55.6	52.8	52.4	53.1	49.9	48.5	41.9	39.1

Table 142: OOP EQ Heatmap by turn card on 9♥8♥4♦ (x/b/c/x)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	44.5	44.3	50.2	57.2	53.3	51.2	52.9	51.4	47.9	44.2	42.7	28.7	30.6
d	43.7	43.8		55.9	52.5	50.6	51.5	50.9	46.9	44.9	43.6	31.4	32.0
h	47.1	47.8	50.1	50.9	50.2	47.6			43.5	44.5	43.0	41.4	39.1
s	44.5	44.3	50.2	57.2	53.3	51.2	52.9	51.4	47.9	44.2	42.7	28.7	30.6

Table 143: OOP EV Heatmap by turn card on 9♥8♥4♦ (x/b/c/x)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	47.6	47.6	47.1	41.6	43.4	44.4	47.2	47.6	46.9	50.1	51.5	58.1	60.9
d	48.0	48.0		42.7	44.1	44.9	47.6	47.8	47.3	50.1	51.4	57.6	60.7
h	47.8	47.6	46.3	44.7	45.1	46.0			48.4	49.3	50.5	54.9	57.6
s	47.6	47.6	47.1	41.6	43.4	44.4	47.2	47.6	46.9	50.1	51.5	58.1	60.9

Table 144: IP EQ Heatmap by turn card on 9♥8♥4♦ (x/b/c/x)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	55.5	55.7	49.8	42.8	46.7	48.8	47.1	48.6	52.1	55.8	57.3	71.3	69.4
d	56.3	56.2		44.1	47.5	49.4	48.5	49.1	53.1	55.1	56.4	68.6	68.0
h	52.9	52.2	49.9	49.1	49.8	52.4			56.5	55.5	57.0	58.6	60.9
s	55.5	55.7	49.8	42.8	46.7	48.8	47.1	48.6	52.1	55.8	57.3	71.3	69.4

Table 145: IP EV Heatmap by turn card on 9♥8♥4♦ (x/b/c/x)

IP does extremely well on high cards, particularly the offsuit aces and kings. The heart ones actually block many of IP's flush combos and result in an EV drop *(Tables 142-145)*.

OOP vs Turn 2/3-pot C-bet: BB vs UTG on 9♥8♥4♦ (40bb) (x/b/c/x/b)

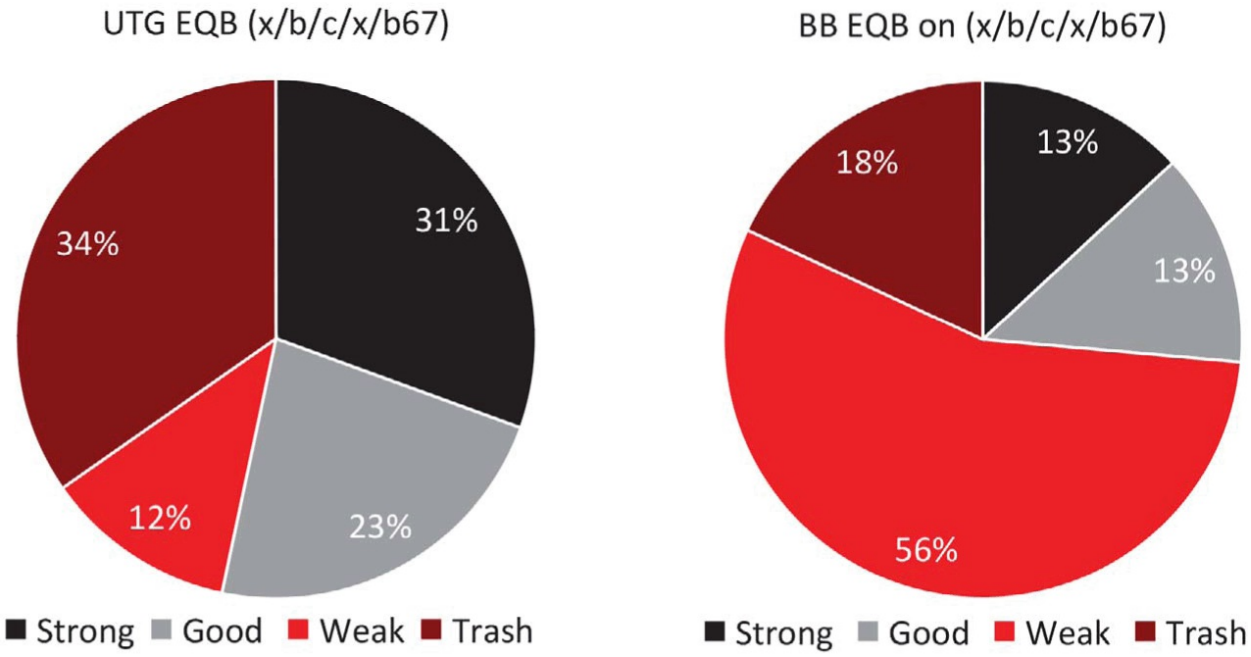


Diagram 128

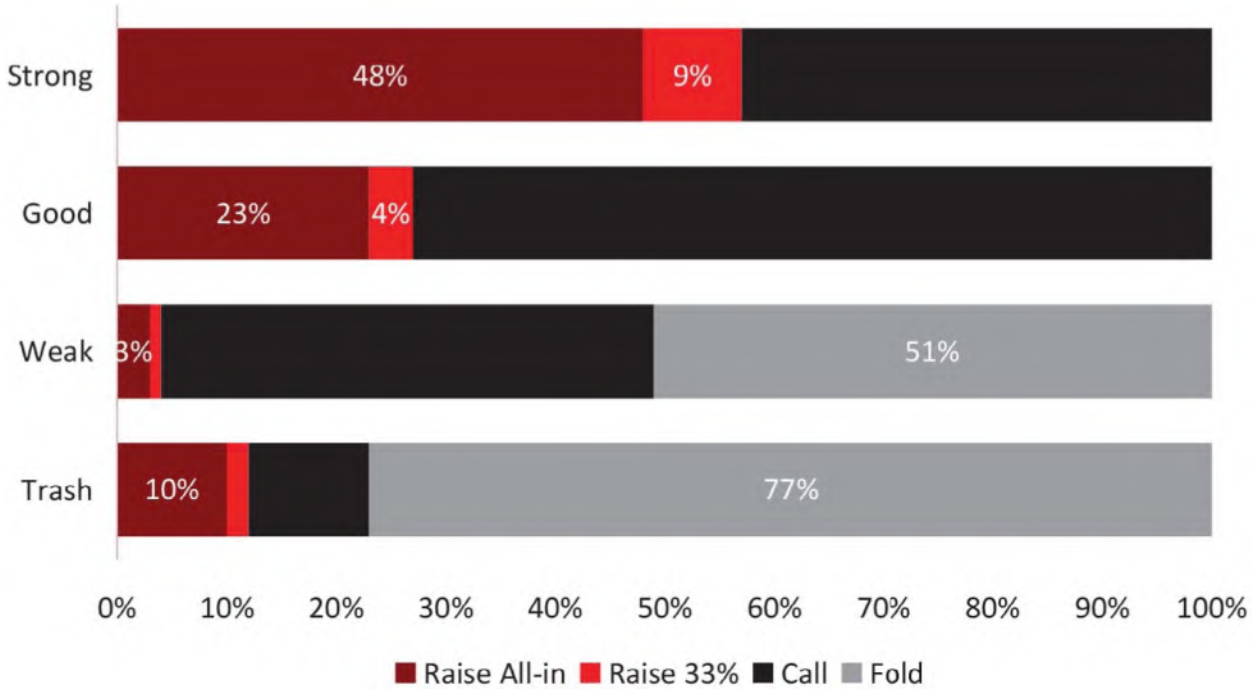


Diagram 129

Facing the second barrel is not great for OOP. At this point, both players have split their ranges several times. IP would be checking back a lot of medium strength hands and is now betting with a very polarized range. OOP would have bet or raised many strong hands by now, so their range is weak against IP's turn c-betting range, resulting in OOP folding, on average, over 40% vs a turn c-bet. Most strong hands will be x/r on the turn, but some will still be slowplayed, leaving OOP's x/c range protected, even on brick runouts *(Diagrams 128-129)*.

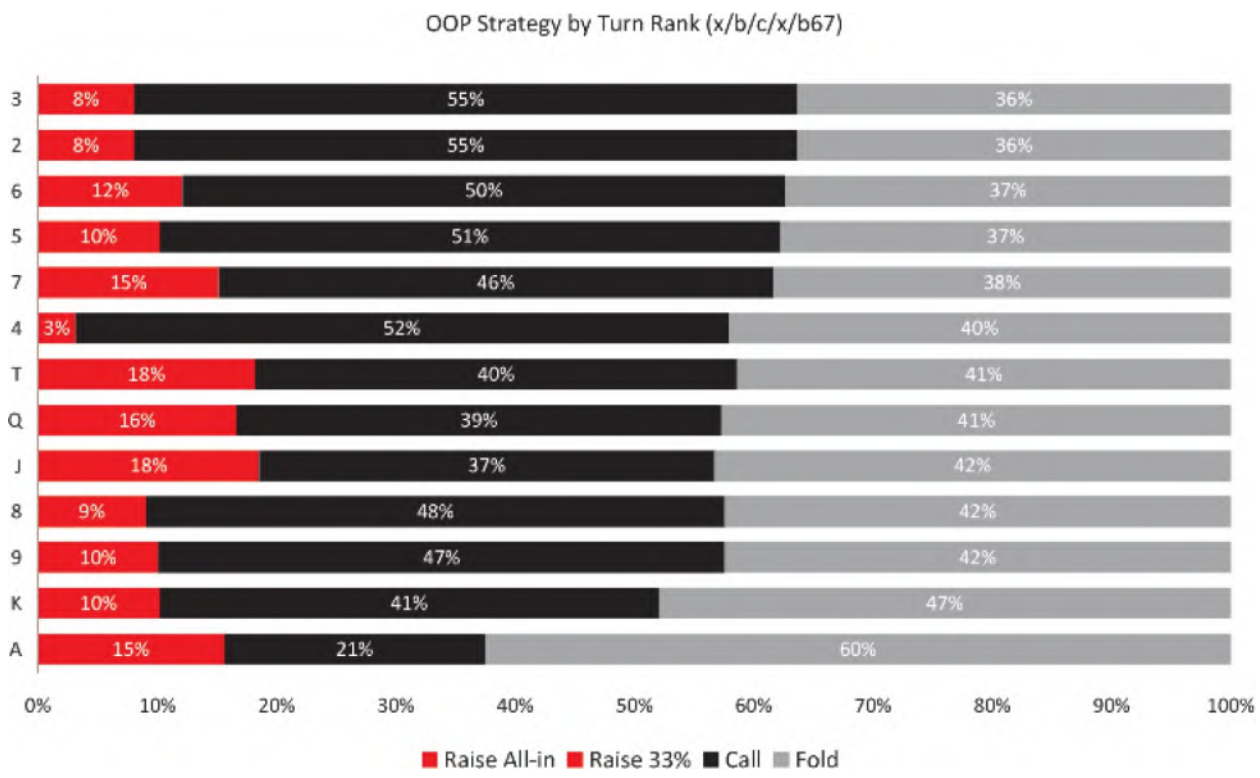


Diagram 130

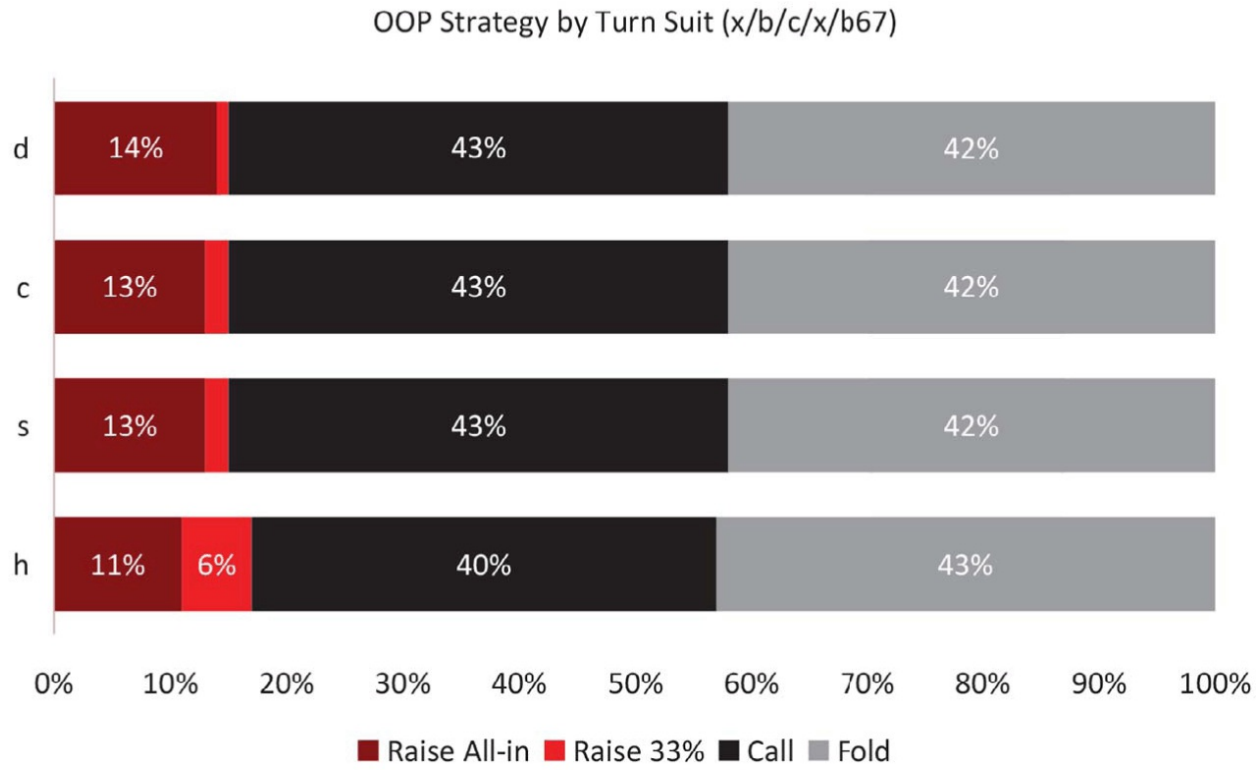


Diagram 131

On average, OOP will x/r the turn 14% of the time and will be mostly going all-in, as a smaller raise size would commit too many chips. In general, their weaker x/r hands are semi-bluffs that will have the equity to call an all-in bet and thus be committed *(Diagrams 130-131)*.

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	43.0	43.1	46.4	46.6	46.1	46.7	47.7	47.0	48.1	47.9	47.2	41.9	41.5
d	43.3	43.4		46.3	46.5	46.4	47.5	46.9	47.5	48.3	47.4	42.4	41.3
h	47.0	47.0	46.9	47.7	47.9	48.4			48.5	49.0	48.9	47.0	46.3
s	43.0	43.1	46.4	46.6	46.1	46.7	47.7	47.0	48.1	47.9	47.2	41.9	41.5

Table 146: OOP EQ Heatmap by turn card on 9♥8♥4♦ (x/b/c/x/b67)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	14.7	14.7	23.7	22.6	20.4	20.7	27.4	25.5	23.8	24.2	23.9	17.0	20.4
d	15.2	15.2		21.6	20.7	20.4	27.2	25.2	22.9	25.0	24.9	18.7	20.8
h	23.9	24.1	21.4	24.9	23.8	23.6			21.9	21.6	21.7	28.1	26.0
s	14.7	14.7	23.7	22.6	20.4	20.7	27.4	25.5	23.8	24.2	23.9	17.0	20.4

Table 147: OOP EV Heatmap by turn card on 9♥8♥4♦ (x/b/c/x/b67)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	57.0	56.9	53.6	53.4	53.9	53.3	52.3	53.0	52.0	52.1	52.8	58.1	58.5
d	56.7	56.6		53.7	53.5	53.6	52.5	53.1	52.5	51.7	52.6	57.6	58.7
h	53.1	53.0	53.1	52.3	52.2	51.6			51.5	51.0	51.1	53.1	53.7
s	57.0	56.9	53.6	53.4	53.9	53.3	52.3	53.0	52.0	52.1	52.8	58.1	58.5

Table 148: IP EQ Heatmap by turn card on 9♥8♥4♦ (x/b/c/x/b67)

Turn Card	2	3	4	5	6	7	8	9	T	J	Q	K	A
c	85.3	85.3	76.3	77.4	79.6	79.3	72.6	74.5	76.2	75.8	76.1	83.0	79.6
d	84.8	84.8		78.4	79.3	79.6	72.8	74.8	77.1	75.0	75.1	81.3	79.2
h	76.1	75.9	78.6	75.1	76.2	76.4			78.1	78.4	78.3	71.9	74.0
s	85.3	85.3	76.3	77.4	79.6	79.3	72.6	74.5	76.2	75.8	76.1	83.0	79.6

Table 149: IP EV Heatmap by turn card on 9♥8♥4♦ (x/b/c/x/b67)

OOP has on average 45% EQ when facing a turn c-bet, but will only be able to realize 77% of it, for a total EV of 21% of the pot. IP has an average EQ of 55%, and will over-realize it by a large margin with an EQR factor of 144%, capturing 79% of the pot.

14

GTO RIVER STRATEGIES

In a sense, the river is the easiest street to play, yet most players struggle with it. In fact, the river is actually where the most mistakes are made and most of the money is won or lost. By the time we get to the river, the pot will generally be a lot bigger than it was on the previous streets. Bigger pots mean bigger bets (often all-in) and, with bigger bets, mistakes can get very costly.

Calculating river equilibrium and exploitative strategies on a given runout from the players' ranges, SPRs and betting abstractions in any decision point is relatively easy, especially with modern GTO solvers. The river calculations typically take a split second. What makes the river challenging is that it is the most difficult street on which to estimate players' starting ranges.

At the beginning of each hand, all players have the exact same range: 100% or 169 strategically unique hands. As the players take different actions, their pre-flop ranges become narrower, so the flop starting ranges aren't too difficult to estimate either. During post-flop play, the players' pre-flop ranges interact with the board in various ways and suits become relevant, forcing us to keep track of specific hand combinations. Post-flop play depends on the way the board runs out and the ranges derived from the previous street actions. All of this makes it significantly more difficult to figure out the players' exact ranges the deeper we are in the hand. Also, since most poker hands are over before showdown, players are a lot less experienced playing the later streets. With all the possible runouts and ways to get to the river, it is no surprise that most players struggle with river play.

Fortunately, we don't have to memorize every single action line and range getting to the river. The river has some unique characteristics that simplify the calculations and make abstract models and toy games particularly useful to accurately represent river scenarios.

- ♦ On the river there are no more cards to come, so the values of the hands are fixed. There are no draws, resulting in each hand having either 100% or 0% equity vs another hand.
- ♦ The hand vs range equity is simply the fraction of the opponent's range the hand beats plus half of the hands it ties with, if there are any. For example, if a hand has 50% equity vs the Villain's range, that means it is ahead of 50% of the Villain's range and behind against the other half.
- ♦ There is a linear ordering of hands in terms of strength that is history independent. This means that the ranking of all possible river hands from strongest to weakest is the same no matter how they got there.
- ♦ There are no future street betting rounds to worry about. Any call or IP check in a heads-up pot immediately ends the hand and realizes equity.

Setting up a River Abstract Model

Setting up this model can be done as follows.

- ♦ List all river hands in both ranges in descending order of strength and split them according to who has them.
- ♦ Assign weights.
- ♦ Establish the blocker effects.
- ♦ Set up a game tree.

Table 150 represents the nuts/air vs bluff-catcher situation with Player1 having a polarized range (50% nut hands, 50% air), and Player2 having 100% bluff-catchers (hand 5) that always lose to the nuts (hand 1) but wins against the bluffs (hand 10). If there are any blocker effects, we can represent them in a matrix as follows *(Table 151)*.

Hand Strength	Player 1	Player 2
1	0.5	0.0
2	0.0	0.0
3	0.0	0.0
4	0.0	0.0
5	0.0	1.0
6	0.0	0.0
7	0.0	0.0
8	0.0	0.0
9	0.0	0.0
10	0.5	0.0

Table 150: Ranges Composition (Polar Versus Bluff-catcher)

Hand	1	2	3	4	5	6	7	8	9	10
1	x		x							
2		x								
3	x		x							
4				x						
5					x					
6						x		x	x	
7							x			
8						x		x		
9						x			x	
10										x

Table 151: Hypothetical Blocker Relationship Matrix

According to the blocker matrix:

- ♦ All hands block themselves
- ♦ Hand 1 blocks Hand 3
- ♦ Hand 3 blocks Hand 1
- ♦ Hand 6 blocks Hands 8 and 9
- ♦ Hands 8 and 9 block Hand 6
- ♦ All other hands do not block each other.

Of course, a real river solution would include many more hands, with different weights and a more complex blocker relationship, but in essence all you need to fully define a river situation are the ranges table, the blocker relationship, and a game tree with the pot size, stack sizes and a betting structure. This is, in fact, how all GTO solvers work. They have a list of all possible rivers and which hands have blockers on each river. The hands are listed in order of strength and the players' ranges tell the solver who has which hand and how often they have it. It doesn't matter how the players got to the specific river situation. As long as they arrive to the overall same structure, the GTO strategy pair in that situation will be equivalent.

For example, the nuts/air vs bluff-catcher situation can be described in a different way with different hands. However, as long as one player has half of their range as the effective nuts, and the other half being air relative to their opponent's range, and the other player's range is 100% of bluff-catchers, then the GTO solution will be the exact same.

Hand Strength	Player 1	Player 2
1	0.00	0.00
2	0.25	0.00
3	0.25	0.00
4	0.00	0.25
5	0.00	0.25
6	0.00	0.25
7	0.00	0.25
8	0.25	0.00
9	0.25	0.00
10	0.00	0.00

Table 152: Ranges Composition (Polar vs Bluff-catcher)

Table 152 also represents a nuts/air vs bluff-catcher situation. P2's range (hands 4-7) can only beat hands 8-9 in P1's range and always loses to hands 2-3. This ranges structure and the ones presented in Table 151 result in equivalent GTO strategies.

This result is of vital importance. If we think about a game tree, there are thousands or possibly tens of thousands of rivers that might come up, so we need to be able to categorize or bucket them into types of scenario that we can identify and solve.

For example, if you can recognize the river situation as being polar vs bluff-catcher, you will know that the GTO strategy for the polar player is to always go all-in with their nut hands and the Alpha % of their bluffs. and the bluff-catching player has to call with 1-Alpha of their range. It doesn't really matter if the nuts are a full house, flush, straight or any combination of those hands. The only important thing would be the overall ranges composition where one player's range is 50% nuts and 50% air, and the other player's range consists of 100% bluff-catchers.

River Abstract Models

The river characteristics we just described make the [0-1] game we studied earlier the perfect fit to analyze the mechanics of river play. In this section, we will look at several river abstract models, compute them in a GTO solver and generate heuristics on how to approach the most typical river situations players can expect to face.

River [0-1] Game Setup

Board: 2♠2♣2♥2♦3♣

Pot: 100 chips

Stack: Players will start with 500 chip stacks, but we analyze examples with different stack depths to understand the SPR effect on the equilibrium strategies.

Heads-up Pot: There are two players involved in the hand, P1 and P2.

Betting Structure: Both players are allowed to bet, x/r, call, go all-in and fold.

Players Hand Strength: This is represented in *Table 153*.

Hand Strength	Hand
1	AA
2	KK
3	QQ
4	JJ
5	TT
6	99
7	88
8	77
9	66
10	55
11	44
12	33

Table 153: Hand Strength

AA is the strongest hand, 33 the weakest and suits will be set up so there are no blocker effects. The blocker effect will be studied later.

This discussion will be centered around two main groups of abstract models:

♦ Polarized with no ranges overlapping between the players.

♦ Linear models where both players can have any type of hand value.

Perfectly Polarized vs Bluff-catcher

The perfectly polarized (nuts/air) vs bluff catcher is the easiest river abstract model to study. We should already be familiar with this river setup. If not, return to Chapter 2 for a quick refresher on this example, as the next river situations will be a variation of this set-up.

Hand	P1	P2
AA	0	0
KK	1	0
QQ	1	0
JJ	0	1
TT	0	1
99	0	1
88	0	1
77	1	0
66	1	0
55	0	0

Table 154: Players Range Composition Table (Combos)

The effective stack size does not affect the general strategy. In this set-up, the polarized player's EV increases with bet-size, and so their equilibrium strategy is to always go all-in with nut hands (KK-QQ) and bluff the air hands (77-66) with an Alpha frequency. Position also doesn't matter. P2 will never bet, and their strategy when facing a bet is to call 1-Alpha of the time with all hands (JJ-88) *(Table 154)*.

All of P1's Range is Stronger Than P2's Range

In the situation in *Table 155*, P2 has 0% equity in the pot. At equilibrium, P2 should never put any more money into the pot and never call a bet of any size. P2 should never bet because P1 will never fold (P1 knows P2's range is capped at 99).

P1 won't bet either since betting won't make any money since P2 will always fold. However in the real world, P2 might not realize they are always beat, so P1 can bet any size they think might induce P2 to make a bad call. I've seen this trick work many times in situations where a player makes a tiny bet when they clearly have zero bluffs and then get called by a weaker player who mucks their hand a second later and mutters "yeah… nice hand."

Hand	P1	P2
AA	1	0
KK	1	0
QQ	1	0
JJ	1	0
TT	1	0
99	0	1
88	0	1
77	0	1
66	0	1
55	0	1

Table 155: All of P1's Range Beats P2's Range

At equilibrium, position doesn't matter in this set-up, but P1 has the option to exploitatively always bet when IP and check or bet when OOP, depending on what P1 thinks will get P2 to put more money in the pot.

P1's Range is Polarized but Has More Nuts Than Air

Hand	P1	P2
AA	6	0
KK	3	0
QQ	0	0
JJ	0	0
TT	0	0
99	0	1
88	0	0
77	0	0
66	0	0
55	0	0
44	1	0

Table 156: P1 Has the Nuts 90% of the Time and Air 10%

In the previous case where all of P1's range is stronger than P2's range, P1's EV is the entire pot. We know that when a player makes a bet, the size of each bet lays different pot odds to the opponent, making a call profitable or unprofitable depending on the bet-size used. Since P1's range is much stronger than P2's range, is there a bet-size so that P2 does not have a profitable call and is then always forced to fold, allowing P1 to win 100% of the pot? *(Table 156)*

Let's make a simple test. The pot is 100 chips. If P1 makes a pot-size bet of 100 chips with all hands, P2's pot odds will be 33% while only having 10% equity with their range, so calling would be -EV. So, the answer to our question is yes. Given P1 has more nut hands than air in their range, if they bet big enough on the river with all hands, P2 won't be able to call, despite having some equity in the pot, resulting in that equity being denied.

If P1 bets too small, giving P2 the right odds to call, P2 will indeed call and P1's EV will be less than the entire pot. So, P1 must bet big enough to force P2 to fold. However, betting too big involves some risk for P1. What happens if P2 slowplayed a big hand or if our assumptions about P2's range were wrong and they show up with a monster hand that we didn't expect?

Even if there are many different large bets that would do the job for P1, we should find the smallest possible bet-size that allows P1 to win the entire pot, achieving maximum EV with the minimum risk. For this, we can find P1's bet-size that will make P2 indifferent to calling and folding when P1 bets their entire range.

$$P2\ EV\ [Call] = P2\ EV\ [fold]$$

$$EQ\ (B + 1) - (1 - EQ)\ B = 0$$

$$EQ\ B\ + EQ - B + EQ\ B = 0$$

$$2EQ\ B - B = -EQ$$

$$-B\ (1 - 2EQ) = -EQ$$

$$B = \frac{EQ}{(1 - 2EQ)}$$

Where:
Starting pot = 1
EQ is P2 equity
B is P1 bet-size

In our example, P2's range only wins when P1 holds 44 and that represents 0.10 of P2's total range. So, P2's EQ against P1 is 10%, and P1's minimum bet-size that allows P1 to win the full pot is:

$$B = \frac{EQ}{(1 - 2EQ)} = \frac{0.1}{1 - (2 * 0.1)} = \frac{0.1}{1 - 0.2}$$

$$B = \frac{0.1}{1 - 0.2} = \frac{0.1}{0.8} = \frac{1}{8} = 0.125$$

$$B = 12.5\%$$

The minimum bet-size that allows P1 to win the full pot is only 12.5% of the size of the pot. If P1 bets any smaller with their entire range, then P2 will have a profitable call *(Table 157)*.

P1 EQ	Bet size
10%	12.5%
15%	21.4%
20%	33.3%
25%	50.0%
30%	75.0%
35%	116.7%
40%	200.0%
45%	450.0%

Table 157: P1 Bet-sizing

If P2 had more equity in the pot, P1's minimum bet-size would get bigger, and even if P2 was ahead of 40% of P1's range, P1 would still be able to win the entire pot by betting 2x the pot.

If P1 has enough chips to force P2 to fold their entire range, then the EV of P1's bluff combos is the same as their value hands. In this example, if P1 bets 12.5% of the pot or more, the EV of AA is 100% of the pot and the EV of 44 is also 100% of the pot, while the EV of P2 is 0.

If P1 has enough chips to make the minimum bet required to win the entire pot with their entire range, P2's equilibrium strategy is to always fold bluff-catchers no matter which bet-size P1 uses. P1 can always obtain an EV of the full pot by betting big enough with bluffs and there is nothing P2 can do to stop this. So, P1 could choose to use a large bet-size with all bluffs combined with the right ratio of value combos, so that they always win the full pot with that bet-size. With excess value hands, P1 could use any other bet-size they think P2 would call and achieve an even larger EV than the full pot. Any time P2 decides to call against any bet-size, P1 could manipulate their range advantageously. For this reason, the only strategy that is always the

highest EV for P2 is to always fold.

In this set-up, position is also irrelevant as P2 will never bet. P1 will bet 100% of the time and P2 will always fold.

When P1 does not have enough chips to make the minimum required bet-size to bet with their entire range, they will be forced to give up with some of their bluffs. They will bet all nut hands alongside the optimal frequency of bluffs (Alpha of their value range) to make P2 indifferent to calling and folding, and P2 will defend 1-Alpha of the time.

P1's Range is Polarized but Has More Air Than Nuts

Hand	P1	P2
AA	1	0
KK	0	1
QQ	1	0
JJ	1	0
TT	1	0
99	1	0
88	1	0
77	1	0
66	1	0
55	1	0
44	1	0

Table 158: P1 has the Nuts 10% of the Time and Air 90%

Since P1's range has more than 50% air, there is no bet they can make with their entire range to force P2 to always fold. P1 has to give up with some of their bluffs and play the polarized vs bluff-catcher strategy with their nut hands by betting as large as possible and then adding enough bluffs to make P2 indifferent between calling and folding *(Table 158)*.

P2 has P1 beat 90% of the time, but their equilibrium strategy is still to always check. P2 cannot bet because P1's range is polarized. P1 knows when they have the best hand and can choose to only call when this is the case.

When facing a bet, P2 has to call with 1-Alpha frequency to make P1's bluffs indifferent, otherwise P1 will incrementally increase their bluffing frequency.

If you ever find yourself in a situation similar to P2 where you have the best hand the majority

of the time but your opponent's range is mostly air, you are forced to play passively despite having the best hand more often than not.

P1 should bet as large as possible so that they can include more bluffs in their betting range. The hands they are bluffing with will still be indifferent to bluffing and checking (if P2 calls 1-Alpha), but the branch of the game tree where P1 gives up will happen less often.

In our example, if P1 has a pot-size bet, they have to go all-in with a 2-to-1 value-to-bluff ratio, so they will go all-in 15% of the time with 10% value and 5% air. Their EV will be 15% of the pot, and P2 will win the pot 85% of the time when P1 has air and gives up. In this set-up, position is irrelevant. Both players will play in the exact same way regardless of position.

Polarized vs Bluff Catcher with Traps

Hand	P1	P2
AA	0	1
KK	1	0
QQ	0	0
JJ	0	0
TT	0	3
99	0	3
88	0	3
77	0	0
66	0	0
55	0	0
44	1	0

Table 159: P1's Range is Perfectly Polarized.
P2's Range is 90% Bluff-catchers and 10% Nuts

As we have seen from the polarized vs bluff-catchers abstract models, the player with the bluff-catcher's range is in a disadvantageous situation and thus players should try to avoid getting themselves in this position. One way P2 can reduce P1's leverage is to slowplay some nutted hands. The slowplayed nutted hands in P2's range are traps *(Table 159)*.

In the polarized vs bluff-catcher model with no traps, P1's EV increases with bet-size, but it is capped at the size of the pot. No player's EV can ever be greater than the pot. If P1 had a strategy that would grant them more than the pot, then P2 could simply revert to a 100% fold strategy and

never lose further chips. Also, the lowest P1's EV can get is 0.5 pot because they have the winning hand 50% of the time. So even if they simply check all the time they still get at least 50% of the pot.

Notice how at a bet-size of about 4x pot, P1 captures 90% of the pot. After that the gains become quite marginal to the point that betting 10x pot will only win about 5% more of the pot, 95% total *(Diagram 132)*.

What happens when P2 has some traps in their range? Is there a cap to how big P1's bet-size can be?

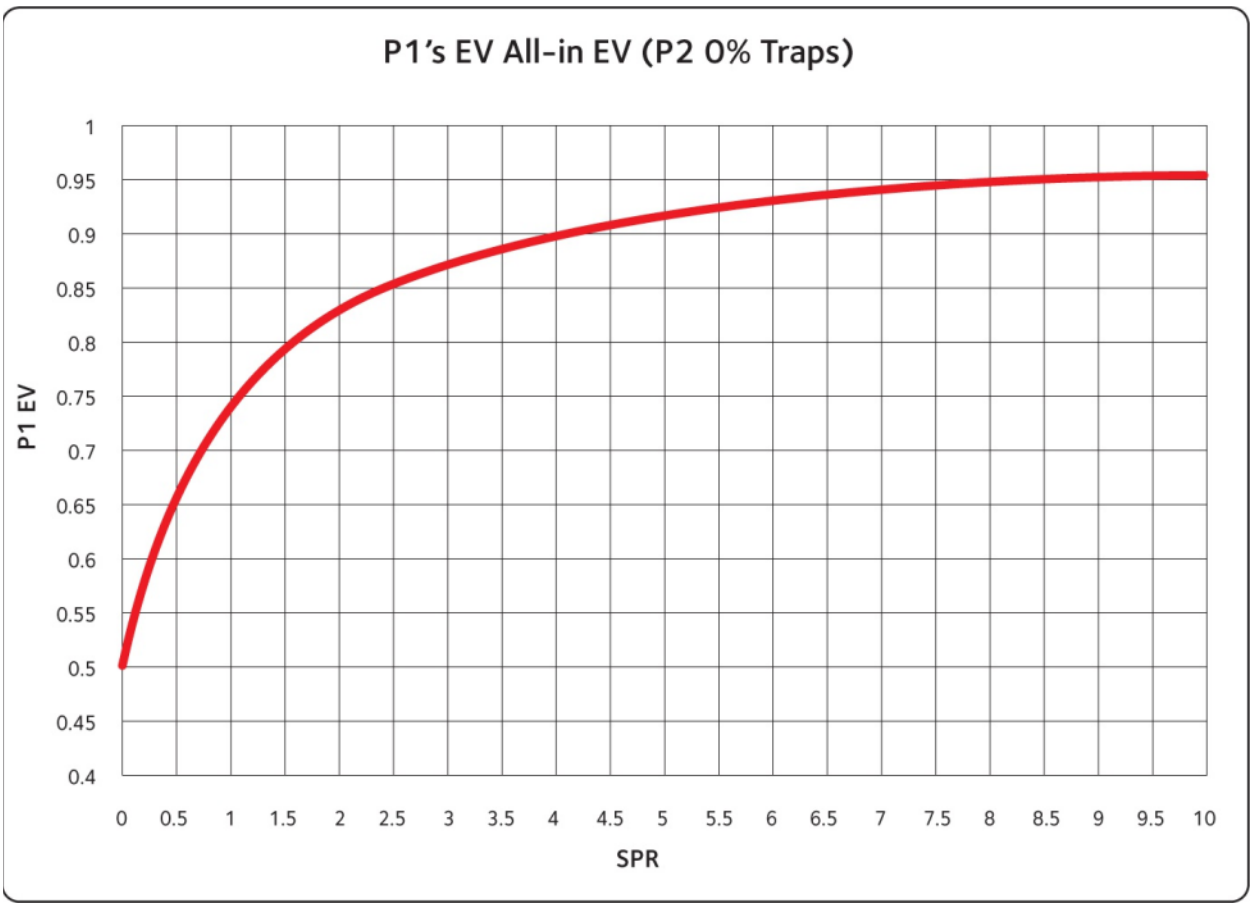


Diagram 132

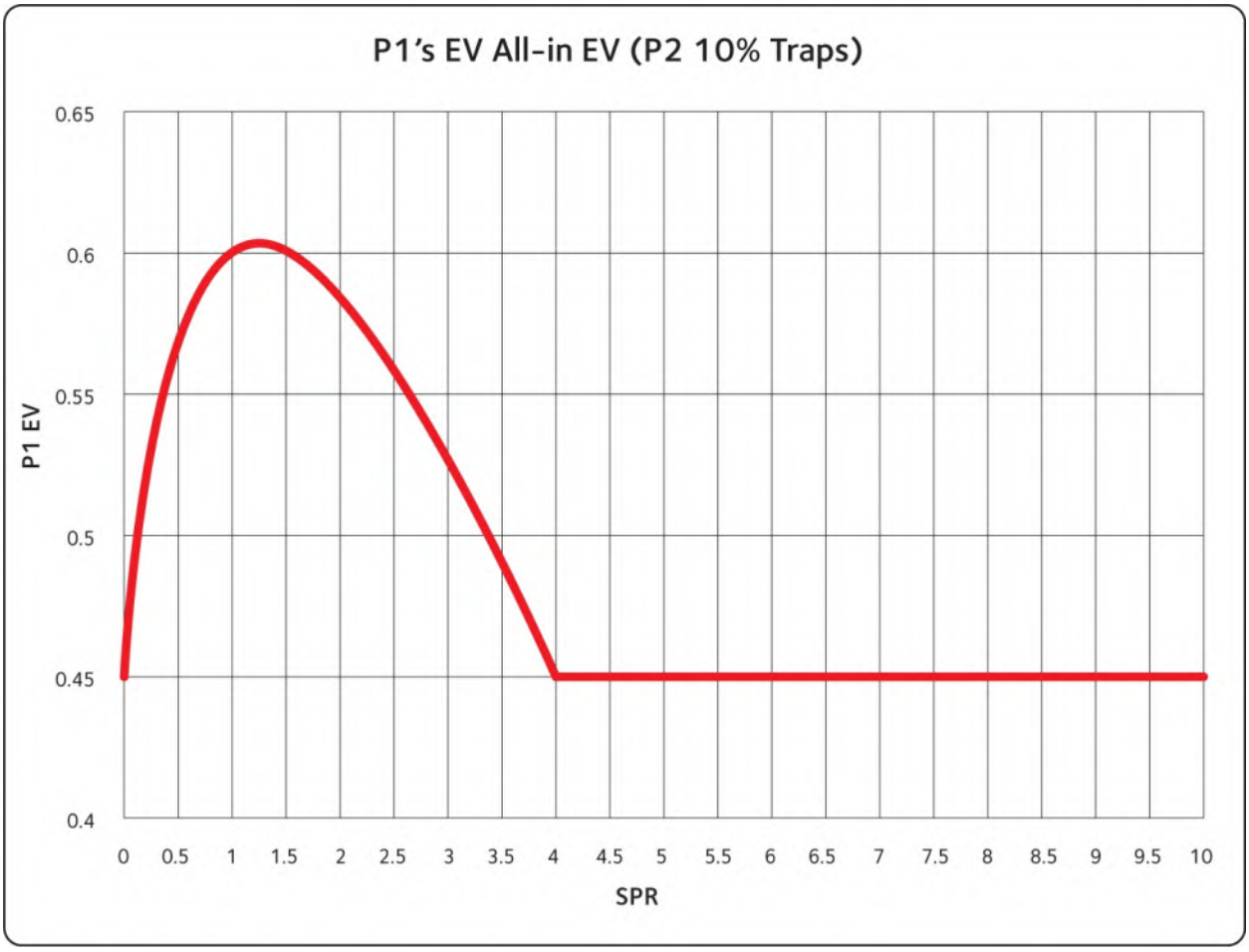


Diagram 133

When 10% of P2's range are traps, P1's EV maxes out at SPR 1.25 *(Diagram 133)*. After that, their EV starts to diminish and P1 is forced to check more frequently until the SPR is so high that they can no longer go all-in profitably, resulting in a checking strategy 100% of the time. When P1 checks (50% of the time), they win the pot 90% of the time, so their EV is 45% of the pot.

Going all-in for a massive overbet when your opponent can have traps is a substantial mistake and will lose you a lot of EV.

With low SPRs, the threat of going all-in and occasionally running into the nuts is not as big an issue, but when SPR gets high, it can be costly and P1 should bet smaller than all-in, particularly if P2 can have a lot of traps.

The problem with betting smaller than all-in is that P2 will now have the option to x/r the river. When P2 x/r, they will be effectively turning some of their bluff-catchers into bluffs and P1's value-bets will now turn into bluff-catchers! This situation is particularly bad for P1 as in

the whole branch of the game tree where they get x/r, P2 will be perfectly polarized against P1, and P2 can increase their EV by x/r bigger. The deeper the stacks, the bigger P2's raise size can be and the more EV will be captured.

There is a trade off between going all-in and using a non-all-in bet-size. To find the exact bet-size B that maximizes P1's EV (which may or may not be all-in), we will borrow the next formula from Will Tipton's Book *Expert Heads-up No-Limit Hold'em*.

$$B = \frac{1 + S - T - 4S\,(1 + S)\,T + \sqrt{(S + 2\,S^2)^2\,T}}{(1 + 2S)^2\;T - 1}$$

(The calculation of this formula requires the use of Calculus and we won't be showing the proof in this text.)

Where:
S = Stack size
B = Bet-size
T = traps %

When P2 can have traps in their range, P1's bet-size actually decreases and the more traps P2 can have, the smaller P1's bet-size becomes to the point where this bet-size approaches 0 and they can no longer bet. At that point, P1 is forced to check their entire range.

In this set-up, position is irrelevant for the small portion of traps in P2's range. P2 will never lead and P1 will always bet nut hands alongside enough air while giving up with the rest of the air. However, if P2 has too many traps, the nature of the game changes and position becomes relevant.

Traps:	1%	10%	20%	30%	40%
SPR	Optimal Bet Size	Optimal Bet Size	Optimal Bet Size	Optimal Bet Size	Optimal Bet Size
0.25	All-in	All-in	All-in	All-in	All-in
0.5	All-in	All-in	All-in	All-in	All-in
0.75	All-in	All-in	All-in	All-in	29%
1	All-in	All-in	All-in	55%	11%
1.25	All-in	All-in	121%	36%	3%
1.5	All-in	All-in	90%	26%	Check 100%
2	All-in	All-in	62%	15%	Check 100%
3	All-in	147%	41%	6%	Check 100%
4	All-in	117%	32%	2%	Check 100%
5	All-in	102%	28%	Check 100%	Check 100%
6	All-in	93%	25%	Check 100%	Check 100%
7	All-in	87%	23%	Check 100%	Check 100%
8	All-in	83%	21%	Check 100%	Check 100%
9	All-in	80%	20%	Check 100%	Check 100%
10	809%	77%	19%	Check 100%	Check 100%

Table 160: P1's Optimal Bet-size by Stack Depth and P2's % of Traps

When stacks are deep enough such that if P2 arrives to the river with too many traps, P1 will start to check back 100% of the time. P2 will miss value from their traps because they will never have the opportunity to win any extra bets. At that point, P2 will be incentivized to start leading some traps which will make P1 bet more often when checked to, and this trade off will eventually reach an equilibrium point where the EV of leading some traps will be the same as the EV of checking them. P2 will then play a mixed strategy, slowplaying just enough nuts to protect their checking range.

> *In general x/r is not a great way to deny your opponent's equity and it is not a great way to get value. What it actually achieves is preventing opponents from value-betting thin and from bluffing a lot when you check to them. Just having 10-20% traps in your range is enough to accomplish both at most stack depths.*

In this set-up, P2 will still defend at the MDF and their calling frequency will be:

$$P2\ Call\ \% = MDF - \%\ Traps$$

Linear Distributions

So far we have focused our discussion of river abstract models where we are able to partition the players' ranges into disconnected categories of hands that were clearly identifiable as nuts, air, bluff-catchers and traps. However, in many real poker situations, both players' ranges will contain a mixture of hands made up from all of these categories.

Since the players' range distributions won't necessarily divide into non-overlapping categories, we need to create a system to categorize these linear distributions.

Categorizing all hands according to their equity with 1 being the strongest hand and 0 the weakest, we can split the ranges into three main sections. These will be with value hands at the top, checking hands in the middle and bluffing hands at the bottom, effectively betting a polarized distribution. If the player is OOP, they will be checking some value hands as traps, so the checking range is not 100% bluff-catchers.

Hand Strength	Hand Category (IP Player)		Hand Strength	Hand Category (OOP Player)	
1	Value		1	Value	Traps
0.9	Value		0.9	Value	Traps
0.8	Value		0.8	Value	Traps
0.7	Bottom of Value		0.7	Bluff-catcher	
0.6	Check Back		0.6	Bluff-catcher	
0.5	Check Back		0.5	Bluff-catcher	
0.4	Check Back		0.4	Bluff-catcher	
0.3	Check Back		0.3	Bluff-catcher	
0.2	Check Back		0.2	Bluff-catcher	
0.1	Strongest Bluff		0.1	Bluff-catcher	
0	Bluff		0	Bluff	

Table 161: Hypothetical River Strategy Example

The bottom value hand as well as the best bluff will be indifferent to betting and checking. The player will *bet all value hands above the bottom value hand* and will *bluff all hands that are*

below the strongest bluff.

The checking range consists of everything in the middle and, for all of those hands, the EV of checking will be higher than the EV of betting.

The player facing a bet will split their range into two main categories, defending hands and folding hands. If the bet-size faced is all-in, the defending player needs to find the threshold hand that is indifferent to calling and folding and call all hands better than that threshold. If the bet-size is not all-in, the defending player will raise all their traps alongside an appropriate number of bluffs.

Hand Strength	Hand Category		Hand Strength	Hand Type	
1	Call		1	Traps	
0.9	Call		0.9	Traps	
0.8	Call		0.8	Call	
0.7	Call		0.7	Call	
0.6	Call		0.6	Call	
0.5	Call		0.5	Call	
0.4	Call		0.4	Call	
0.3	Call		0.3	Call	
0.2	Fold		0.2	Bluff	Fold
0.1	Fold		0.1	Bluff	Fold
0	Fold		0	Bluff	Fold

Table 162: Hypothetical River Strategy Example

The key to river play when players have linear distributions consists of correctly identifying these threshold hands. In the very simple example where the players' ranges are symmetric, OOP can only bet or check, and their checking hands have zero equity. If OOP bets, IP can call or fold.

The next equations explain the very simple example where all the checking hands have 0% equity and players can only bet, check and call, but not raise.

$$h_c = \frac{b}{b+p}$$

$$h_b = \frac{EQ\ h_c\ (p+2b) - b}{b+p}$$

Where:
b = bet size
p = pot size
h_c = defending player threshold calling hand
h_b = betting player threshold betting hand
EQh_c = equity of the threshold calling hand

In this example, the betting player will bet all hands that are better than h_b and simply give up with the rest. The defending player will call all hands that are better than h_c and fold the rest.

Example
Assume the players are going all-in for a pot sized bet with

b = p = s
s = stack size

The threshold calling hand for the defending player will be:

$$h_c = \frac{1}{1+2} = \frac{1}{2}$$

Given the ranges are symmetric, then

$$EQh_c = h_c = \frac{1}{2}$$

and the threshold betting hand for the betting player is:

$$h_b = \frac{\frac{1}{2}(1+2)-1}{1+1}$$

$$h_b = \frac{\frac{1}{2}(3)-1}{2} = \frac{1}{4}$$

In this case, the betting player's threshold is 1/4, which means they are betting all better hands, so 3/4 of all hands. Since the defending player is getting 2-to-1 pot odds, 2/3 of the betting hands beat h_c and the other 1/3 of hands, which lose to h_c, are pure bluffs since they never win when called.

For more complex situations where the checking hands have equity and players can raise, the equations are far more complex, and calculating the threshold hands by hand is not possible in most cases. For this reason, the best approach to study river abstract models with linear distributions is to replicate them in a GTO solver. In the next section, we will go over a couple of these examples, but I encourage the reader to test these and other situations in order to get proficient with the general strategies.

Symmetric Range

Hand	P1	P2
AA	1	1
KK	1	1
QQ	1	1
JJ	1	1
TT	1	1
99	1	1
88	1	1
77	1	1
66	1	1
55	1	1

Table 163: Both Players Have the Exact Same Range

We already studied this type of linear distribution *(Table 163)* in the [0-1] Single Street Toy Game section, but it had the constraint of OOP always checking to IP. This time, we will study equilibrium play when OOP is allowed to bet the river.

SPR	All-in	Bet 1/3-pot	Check
10	0	37%	63%
5	0%	33%	67%
2	0%	35%	65%
1	0%	31%	69%
0.75	31%	0%	69%
0.50	38%	0%	62%
0.25	62%	0%	38%

Table 164: OOP Strategy (First Action)

With SPR of 1 or more, OOP will check middle strength hands TT-66 alongside most AA-KK for protection. They will bet with QQ-JJ plus the rest of their AA and KK as well as 55 as a bluff, using a 1/3-pot bet-size.

With SPR 1 or less, OOP's strategy is to go all-in with most of the top of their range JJ+, while checking about 10-20% of them to protect the checking range and to bluff with 55. As the SPR gets shallower, OOP's value range expands from JJ+ at 0.75 SPR to 99+ at 0.25 SPR *(Table*

164).

With SPR 5+, IP never goes all-in after OOP checks. Their strategy consists of splitting their range between pot and half-pot bet-sizes, betting pot with most AA – KK, while also using some in the smaller size to protect against being x/r, while checking back their middle strength hands TT-77. QQ-JJ are bet using the half-pot bet-size. 55 and some 66 are used as bluffs in both bet-sizes *(Table 165).*

SPR	Bet 200	Bet 100	Bet 75	Bet 50	Bet 25	Check
10	0%	21%	0%	27%	0%	52%
5	0%	22%	0%	27%	0%	51%
2	11%	0%	35%	0%	0%	54%
1	0%	42%	0%	0%	0%	58%
0.75	0%	0%	45%	0%	0%	55%
0.50	0%	0%	0%	61%	0%	39%
0.25	0%	0%	0%	0%	77%	23%

Table 165: IP Strategy Versus Check

With SPR 2, IP will go all-in with most of their AA-KK, using the smaller size for QQ and some JJ, bluffing 66-55 and checking back TT-77. With SPR 1 and under, IP will check back all middle strength hands TT-77, go all-in with a polar range of JJ+ and 55-66, expanding their value range as SPRs gets smaller to include 88+ with SPR 0.25.

Ranges Overlap in the Middle

In this situation, some hands in P1's range are stronger than all of P2's range and some hands in P2's range are weaker than all of P1's Range *(Table 166).*

Hand	P1	P2
AA	1	0
KK	1	0
QQ	1	1
JJ	1	1
TT	1	1
99	1	1
88	1	1
77	1	1
66	1	1
55	1	1
44	0	1
33	0	1

Table 166: Some P1 Hands Beat all P2 and Some P2 Lose to all P1

P1 is IP and P2 is OOP

When P2 is OOP, they will never bet unless the SPR is very small.

SPR	All-in	Bet 125	Check
10	38%	16%	46%
5	37%	16%	47%
2	33%	16%	51%
1	60%	0%	40%
0.75	57%	0%	43%
0.50	53%	0%	47%
0.25	60%	0%	40%

Table 167: P1 Strategy Versus Check

After P2 checks, P1 will have two different bet-sizes when SPR is 2+, all-in and 125%-pot. The all-in bet-size will be used with the nut hands P2 cannot have (AA-KK), and the 125%-pot bet-size will be used with the value range that overlaps with P2's range (QQ). 55-66 plus some 77 will be used as bluffs and the middle strength hands (JJ-77) are checked back.

With SPR 1 and below, P1 will check back middle strength hands (TT-77) and will go all-in with a polarized range of AA-JJ for value and 55-66 as bluffs *(Table 167)*.

P1 is OOP and P2 is IP

SPR	All-in	Bet 25	Check
10	32%	37%	31%
5	31%	31%	38%
2	38%	22%	40%

Table 168: P1's Strategy (OOP First Action) with SPR Above 2

With SPR 2 or more, P1 likes to develop two different bet-sizes, all-in, which will be used with the nut hands P2 cannot have in their range (AA-KK), and a smaller 25%-pot bet-size with the top of their range that overlaps with P2's range (QQ-TT). 66-55 are used as bluffs and 99-77 are checked alongside a very small fraction of AA-KK and most of QQ to protect P1's checking range *(Table 168)*.

With SPR 1 and below, P1 will also develop the use of two different bet-sizes, all-in and a smaller 10%-pot size. The all-in bet-size will be used with a polarized range of JJ+ and 66-55, and the smaller bet-size will be used with TT-99, a sliver of AA-JJ and some 66 as bluffs. The checking range will be 88-77 plus a small frequency of TT+ for protection. As the SPR gets shallower, P1 gets to jam more hands and starts to move TT-99 into the all-in range *(Table 169)*.

SPR	All-in	Bet 10	Check
1	47%	24%	29%
0.75	50%	18%	32%
0.50	51%	30%	19%
0.25	64%	14%	22%

Table 169: P1's Strategy (OOP First Action) with SPR Below 2

SPR	All-in	Bet 75	Bet 50	Check
10	0%	0%	32%	68%
5	0%	30%	0%	70%
2	0%	32%	0%	68%
1	39%	0%	0%	61%
0.75	45%	0%	0%	55%
0.50	52%	0%	0%	48%
0.25	60%	0%	0%	40%

Table 170: P2's Strategy Versus IP Check

After P1 checks, P2 will be checking back middle strength hands (99-66) and will bet a polarized range with QQ-TT for value and bluff some frequency of their weakest hands (55-33). When stacks are very deep, P2 cannot use a large bet-size because they risk getting x/r, but as stacks get shallower, P2 can increase their bet-size to 75%-pot, and with an SPR of 1 and less, P2 will simply go all-in with their betting range *(Table 170)*.

Blocker Effects

For this section, we will modify the board and ranges as follows:

Board: 8♥3♥3♣2♥2♦
Pot: 100 chips
Effective Stack: 500 chips
Betting Structure: Villain always checks to Hero, Hero can bet 25, 50, 100 or all-in. If Hero uses a non all-in bet-size, Villain can x/r all-in.

Blocker Example 1

Hero is IP with a range of:

- ♦ 9 combos of nut flush: A♥K♥-A♥9♥, A♥7♥-A♥4♥
- ♦ 12 combos of nut blocker: A♥Kx, A♥Qx, A♥Jx, A♥Tx
- ♦ 24 combos of lower flush blocker: K♥Qx, Q♥Jx, J♥Tx, T♥9x, 9♥8x, 7♥6x, 6x5x, 5♥4

♦ 6 combos of non-flush blockers: 7♠6♠, 7♠5♠, 7♠4♠, 6♠5♠, 6♠4♠, 5♠4♠

Villain is OOP with a range of 45 flush combos that aren't blocked by the board:

♦ 9 combos of nut flush: A♥K♥-A♥9♥, A♥7♥-A♥4♥

♦ 8 combos of K-high flush: K♥Q♥-K♥9♥, K♥7♥-K♥4♥

♦ 7 combos of Q-high flush: Q♥J♥-Q♥9♥, Q♥7♥-Q♥4♥

♦ 6 combos of J-high flush: J♥T♥-J♥9♥, J♥7♥-J♥4♥

♦ 5 combos of T-high flush: T♥9♥, T♥7♥-T♥4♥

♦ 4 combos of 9-high flush: 9♥7♥-9♥4♥

♦ 3 combos of 7-high flush: 7♥6♥-7♥4♥

♦ 2 combos of 6-high flush: 6♥5♥, 6♥4♥

♦ 1 combo of 5-high flush: 5♥4♥

In this set-up, the Villain will never bet, even though all of their hands are flushes, because Hero's range is polarized. Hero either has the nuts or a bluff. Clearly Hero has many more bluffs than value combos so, at equilibrium, cannot bet them all. In this case, what type of hands would make the best bluffing combos for Hero, and what would be the optimal bet-size?

This situation is similar to the polarized vs bluff catchers with traps abstract model but in this situation, if Hero has the nuts or the nut blocker, then the Villain's range contains zero traps. For this reason, the best bluffing combos for Hero are the nut flush blocker. By betting only with the nut flush and the nut blocker, Hero is effectively turning the game into the polarized vs bluff catchers toy game and, as we know, Hero will maximize EV by going all-in with all value combos and just enough bluffs to make the Villain indifferent to calling and folding. In fact, bluffing with non-nut blockers will lose Hero EV. The Villain has to defend 1-Alpha of their range to make Hero's bluffs indifferent to betting and checking.

In this situation, the GTO solver might show a higher calling frequency than expected for the Villain. This occurs because the solver accounts for the calls with the "ghost" nut flushes that the Villain never really has. Ignoring the 9 nut flush combos, the Villain's calling frequency will be exactly 1-Alpha. Some GTO solvers have the option to display real frequencies.

Blocker Example 2

Hero is IP with a range of:

♦ 9 combos of nut flush: A♥K♥-A♥9♥, A♥7♥-A♥4♥

♦ 24 combos of lower flush blocker: K♥Qx, Q♥Jx, J♥Tx, T♥9x, 9♥8x, 7♥6x, 6x5x, 5♥4x.

♦ 6 combos of non-flush blockers: 7♠6♠, 7♠5♠, 7♠4♠, 6♠5♠, 6♠4♠, 5♠4♠

Villain is OOP with a range of 45 flush combos that aren't blocked by the board:

♦ 9 combos of nut flush: A♥K♥-A♥9♥, A♥7♥-A♥4♥

♦ 8 combos of K-high flush: K♥Q♥-K♥9♥, K♥7♥-K♥4♥

♦ 7 combos of Q-high flush: Q♥J♥-Q♥9♥, Q♥7♥-Q♥4♥

♦ 6 combos of J-high flush: J♥T♥-J♥9♥, J♥7♥-J♥4♥

♦ 5 combos of T-high flush: T♥9♥, T♥7♥-T♥4♥

♦ 4 combos of 9-high flush: 9♥7♥-9♥4♥

♦ 3 combos of 7-high flush: 7♥6♥-7♥4♥

♦ 2 combos of 6-high flush: 6♥5♥, 6♥4♥

♦ 1 combo of 5-high flush: 5♥4♥

In this set-up, we removed the nut blockers from Hero's range. Just as before, the Villain will never lead into Hero. Now that Hero does not have the nut blocker, what should their strategy be? Should they still go all-in or should they use a smaller bet-size than previously?

Now that Hero does not have the nut blocker, they can no longer remove the traps from the Villain's range. Going all-in for a large overbet without the nut blocker will lose Hero a lot of EV so, in this case, Hero will be betting the size of the pot.

Which combos are now best to use as bluffs? When I ask this question to my students, many rush to say that now that the nut blocker is missing, Hero should be using the second nut blocker (K♥) combos. However, in reality, no blocker is better than a non-nut blocker. The solver prefers

to bluff with the low spade combos instead. The reason for this is because if Hero chooses to bluff a given flush blocker, say the K♥ combos, the solver could adjust to start overfolding the king-high flushes and calling with more of the lower flush combos.

If we add a few nut blocker combos to Hero's range, but not enough to go all-in with their entire value range, Hero will split their value range into two sections, going all-in with as many nut combos as can be accommodated plus the nut blockers, and betting full pot with the rest of the value range, using the low spade combos as bluffs.

For SPR 1 and lower, Hero's bet-size will always be all-in if they have enough nut blocker combos. Hero should go all-in with enough blockers to make the Villain indifferent, and give up the rest. If there are not enough nut blockers in Hero's range, they can complete their bluffing frequency with low spade combos. If Hero has more flushes in their range other than the nut flush, then flush blockers become more valuable and are higher EV bluffs than non-flush blockers.

Practical Applications

This section is a quick summary of the most important river characteristics and how to apply them in-game.

OOP River Betting

Range composition that favors a high x/r frequency vs OOP bet

- ♦ OOP has a lot of hands that want to realize equity. Having many traps reduces IP's overall betting frequency and helps OOP realize equity.
- ♦ OOP has a small number of strong hands but they are nutted.
- ♦ IP has a range structure that makes them want to bet at a high frequency after a check.
- ♦ x/r protects OOP from IP's thin value-bets.
- ♦ On dry boards after x/c x/c, OOP will usually not have much pure air and will often use hands like bottom pair that are typically x/f as x/r bluffs.

Why bet from OOP

- ♦ Fundamental difference in position is that IP's checks realize their equity. Betting from OOP prevents IP from realizing equity for free.
- ♦ Range compositions determine how much the opponent wants to bet and check. Generally, you want to bet when IP wants to check back often.

OOP bets rivers after IP checks back the turn

- ♦ On average, IP's range after checking back the turn will be more condensed and OOP's range will be more polarized.
- ♦ OOP should bet the river at a reasonable frequency, approximately 20-30% of the time.
- ♦ If IP checks back on a high betting frequency turn, that makes their range getting to the river a lot weaker, while if they check back a relatively bad turn, the check back range will be stronger.

OOP leads river after x/c, x/c

- ♦ On average, after IP bets twice, their range will be very polarized and OOP's range will be more condensed. Most of OOP's hands after x/c, x/c want a cheap showdown.
- ♦ After x/c, x/c, the situations where OOP wants to donk bet the river are somewhat rare. They usually occur when the river card, or often the turn and river card together, significantly shift the polarization of the ranges. When this happens, OOP will unexpectedly have many strong hands and IP will tend to want to check back the river at a high frequency. Donk bet frequency can be 75%+ in these cases.
- ♦ While the cases requiring river donk bets are rare, the EV impact is usually high enough to be worth studying. Some examples are four-flush and four-straight boards, when the river pairs the second highest card on the board, and runner-runner pair.

IP River Betting

Betting from IP is much simpler than betting from OOP. After OOP has checked, their range will generally be weak and mostly made of bluff-catchers. If your range is polarized, bet as big as you can and add enough bluffs to make OOP indifferent to calling and folding. If your range is condensed, check back your middle strength hands, bet the top of your range and use the weakest hands as bluffs.

If your range is not very nutted, you can still value-bet, but choose a small bet-size, particularly if OOP can be trapping. If your range is too weak or OOP can have too many traps, checking back and taking a free showdown is usually good. Don't forget to always add a small frequency of your nutted hands to your small bet-size so you are protected against x/r, although this is unnecessary if OOP has no traps.

IP Play vs River Bets

The best exploit vs players who don't bet the river often enough is to value-bet less thinly and to fold the river more often when they bet. If you know OOP won't be betting the river too often, you can get away with c-betting the flop a lot more. This is because your EV when you called is higher, as you get a lot of free showdowns and get to realize the equity of many marginal hands that you wouldn't normally be able to.

Conversely, the best exploit vs players who frequently bet the river after turn checks is to not c-bet the flop too often, so you don't end up with as much air that has to check back the turn and then fold to a river lead. From IP, it is important that you check back the turn with some hands that are capable of raising river bets, otherwise OOP can get away with a lot of betting if IP's range contains too much air/bluff catchers.

River Calling Strategies

Blockers

- ♦ On the river, all bluff-catchers are equal except in how they block value hands and don't block bluffs.
- ♦ When you block the opponent's value range, call more often.
- ♦ When you block the opponent's bluffing range, fold more often.
- ♦ When you block the opponent's value and bluffing range, look for other decision points.

♦ When you have no blockers, it is irrelevant, or slightly negative.

River Call Decision Points

♦ Use their value range as a starting point. Even against very tight players, always call hands in their value range.

♦ Never call with bluff-catchers if the Villain doesn't have enough bluffs.

♦ If there is a lot of air in the Villain's range, they will be more likely to be bluffing.

♦ Perception matters. If we are perceived to be a calling station, assume an expanded value range. If we are perceived as weak, expect a narrow value range (and wider bluffing range).

♦ Defending close to 1-Alpha is a good approximation in most river spots.

You can use the knowledge of the river set-ups to improve your pre-flop, flop, and turn play. If you know beforehand what the best possible river scenarios are for you, then all your earlier street play should focus on arriving to those beneficial river situations. At the same time this maximizes the likelihood of you getting there more often with the correct range composition.

Your opponents will be doing the same and this is exactly how GTO solvers work out the equilibrium strategies on earlier streets. They work out turn strategies that lead to the optimal river situations, then they also work out the flop strategies that lead to those turn situations. They then repeat this for pre-flop play. All of this is done with the single goal of maximizing each player's EV by creating the most profitable situation possible that leads to the most profitable future situations. This happens until equilibrium is reached and both players are playing GTO. Failing to do so at any point during a hand creates imbalances that will inevitably lead to unfavorable situations that your opponents can exploit, and that is what exploitative play is all about.

FINAL WORD

We have covered a lot of ground in *Modern Poker Theory* but there is far, far more to the game of poker than could ever be covered in a single volume. My goal when writing this book was not to solve the entire game and give all the answers but to provide the reader with the tools needed so that they can find the answers themselves.

As science and technology progress they shape our world and, with it, the game of poker we all love. New software and strategies will continue to emerge but they will be useless unless we understand the fundamentals of the game. Once we have achieved this learning, we can use the tools to increase our edge. Realize that the results from tools are not oracles that should be followed blindly.

Writing this book has been an amazing experience. I am incredibly thankful for having the opportunity to share my thoughts with you all and I sincerely hope I was able to help you get a step closer to achieving all your poker goals and dreams.

Best of luck and see you at the tables.

Michael Acevedo