Investigation of the Sicilian Defense: Winning rates and strategic discrimination

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Abstract:

Chess games demonstrate players' ability to envision the situation on a large scale, cope with variations, and take precautions. It's been proven statistically and mathematically that the white sides are more likely to win due to offensive advantage. Nonetheless, utilizing numerous defensive gambits, the black enhances its chances of succeeding, among which the Sicilian defense ranks the top. Characterized by asymmetrical arrangements, the Sicilian defense carves the path for the queen while not waiving to occupy central positional advantages. Dating back to its origin in the 16th century, it has prevailed since the mid-20th century and has now developed its most complex variations in response to white's first move, "e4". In this research, whether there is a significant difference in the winning rate of each variation is examined, and the payoffs for them are evaluated mathematically for a theoretically optimized strategy.

Keywords: Chess games; Sicilian defense; Chi-square Test

1 introduction

Chess is the oldest type of chess in the world, with a history of over 2000 years of development. It is an intellectual game played by two players. Chess originated in Asia and later spread to Europe, becoming a popular form of international chess. To win, chess players constantly explore the routines of international chess. A chess game can be roughly divided into three stages: opening, middle, and ending. The beginning is to serve the mid to late stages of the game, so although there is no fixed beginning for international chess, through continuous learning, players have found that the beginning has certain principles and principles, mainly including activating their pieces as much as possible, seizing the center position of the game, and protecting their king as much as possible. Only by following principles can one play chess well. The opening generally refers to the first 10-15 rounds. Generally, the opening of chess is divided into 5 categories, mainly including open opening, semi-open opening, semi-closed opening, and closed opening. There are many subcategories under each major category. The opening names are mostly named after the black side because the white side takes the lead, so the white side must have a certain degree of initiative in the production and control center. The difference in these opening names is how the black side breaks the white side's central control.

With a history of approximately 300 years, Sicilian Defense is the most well-known semi-open opening strategy. Sicilian Defense has developed a series of variations, becoming the most complex opening. Challenges have been proposed, however, to the values of some marginal variations. Empirically, for either the white or black, are some variations comparably inferior? A statistical test examines whether a significant discrepancy exists in winning rates for each variation. Also, their payoffs are evaluated mathematically for a theoretically optimized strategy.

2. The Homogeneity of Winning Rates

As a semi-open opening method, the Sicilian defense has over ten variations. In this part, winning percentages of variations of the Sicilian defense are counted from Lichess.org, a famous website for advanced chess battles, as sampling statistics. In terms of detection methods, this article uses the chi-square test to test whether there will be any difference in the victory rate after using different variants of Sicilian defense at the beginning of the game. The chi-square test is conducted because the variable—a type of variation—is categorical data. If the conditions are met, a chi-square test for homogeneity of winning rate among different gambits will be adopted.

The data for this article is sourced from Lichess.org, a very famous chess game website. From the perspective of players on the website, the source of players is extensive, and in chess, players do not have preferences for different combat applications. This means that from the data source, the data from Lichess can approximately represent the game data of all players. This data is robust, and the Chi-square test's requirement for simple random samples is met.

The sample consists of 10,000 games for each variation. There must be at least 100,000 games played daily. It is

reasonable to assume that n<N/10, where n is the number of games in the sample, and N is those in the population, represented by all chess players. This equation guarantees that each game is independent of the others. The condition of independence is met.

Due to the vastness of the sample size, the expected values (the product of frequency and number of games) of each variation are at least 5. As a result, the "large counts" condition is met.

After obtaining relevant data, we made the following assumptions. The null and alternative hypotheses are:

H_0: $p_{Najdorf}=p_{Dragon}=p_{Classical}=\ldots=p_i$

H_a: At least one p is not consistent with each other,

Where p_i represents the winning percentage of black of the "i" variation. The significance level is kept at 0.05.

The Results are shown in Table 1.

Table 1: The data of proportions of wins for 13 variations

	Gambits	Najdorf	Dragon	Classical	Scheveningen
Proportions	White	0.47	0.46	0.48	0.47
	Draw	0.05	0.05	0.04	0.04
	Black	0.48	0.49	0.48	0.49

	Gambits	Open	Closed	Wing gambit	Old Sicilian
Proportions	White	0.49	0.49	0.49	0.47
	Draw	0.04	0.04	0.04	0.04
	Black	0.47	0.47	0.47	0.49

	Gambits	Pin variation	McDonnell attack	Bolder attack	Smith-Morra gambit	Staunton-Cochrane variation
Proportions	White	0.45	0.48	0.45	0.47	0.46
	Draw	0.04	0.03	0.04	0.04	0.04
	Black	0.51	0.49	0.51	0.49	0.50

From the results, there is not much difference in the proportion of black side winning among different variants, with the lowest proportion being 47% and the highest being only 51%. For further analysis, this article uses the Chi-square test to test the original hypothesis. The results are shown in Table 2.

Table 2: The computer output of the chi-square test for homogeneity of winning percentages.

"Title"	"χ^2 2-way Test"
"χ^2"	2.1356931319944
"PVal"	0.99999999828213
"df"	24.
"ExpMatrix"	"[...]"
"CompMatrix"	"[...]"

From the results, the P-value of the test is very close to 1, far higher than the significance level of 5% we set. This indicates that the Chi-square test is almost completely unable to find evidence to reject the original hypothesis. In other words, through the Chi-square test, this article did not find evidence to prove that different variants of Sicilian defense would lead to different victory rates.

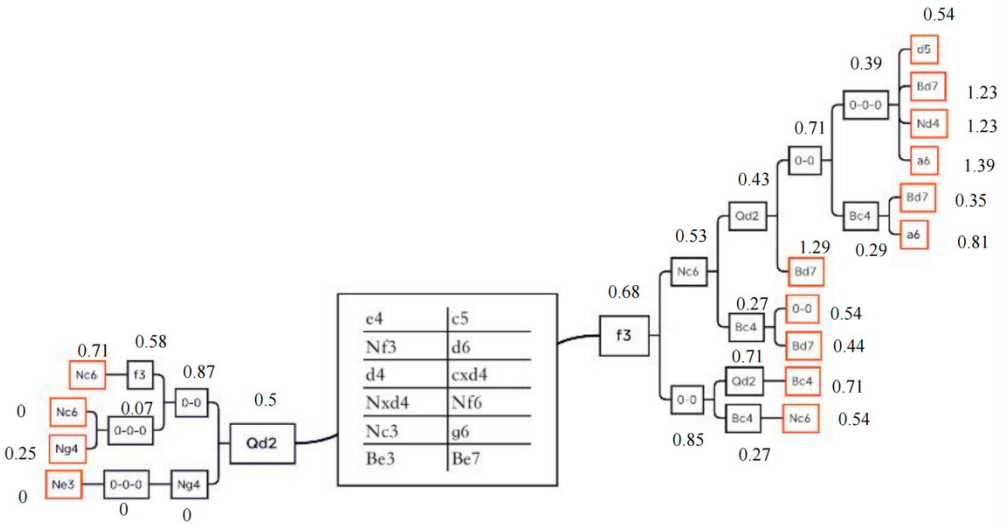
3. Payoff analysis

We have not found suitable evidence from the previous text to prove whether different variants lead to different winning rates. Still, new questions have been raised: Will there be a dominant way to achieve the highest payoff for each step under a variant? To study this issue, this article selects the dragon variant in Sicilian defense for analysis.

As one of the common gambits, the Dragon Variation has been well-famed for black's fortress bishop, the one maintaining the control of diagonal while keeping a safe position. The Dragon variant is one of the most complex routes in Sicilian defense. The target of the black side is a sharp and aggressive attack, putting the white side under pressure from the beginning. This line is full of tactical thinking, suitable for players who want to fight for victory. As discovered in the last part, the homogeneity of the winning probability for each variation has been guaranteed. Similarly, different moves, specifically in the Dragon Variation, should be equally forceful. An analysis of the advantages of different ways to cope with changes is conducted.

In this part, the principle of game theory is utilized. In terms of payoffs, engine analysis of situational advantages is referred to. As the sport was conquered by artificial intelligence in 2005, the engine gives the most accurate evaluation. Consequently, using parameters provided by machines would be authoritative.

To begin with, the main variations of the Sicilian Defense and their engine-analyzed advantages are summarized below to determine the potential dominant or inferior moves.



Graph 1: Tree diagram of the Sicilian Defense and Payoffs

Note: The upper-case letter in the records represents chess pieces, while lower-case ones and numbers coordinate the movement. To point out, "x" means capture.

Moreover, the payoffs for the results of each approach are calculated. The table below presents the average estimate of situational advantages (cumulative points divided by the number of moves) evaluated by engines. The results are shown in Table 3.

Table 3: Average payoffs for each variation.

Evaluation	(0.5,0.593)	(0.5,0.823)	(0.5,0.823)	(0.5,0.877)
	(0.467,0.683)	(0.555,0.91)	(0.555,0.535)	(0.505,0.485)
	(0.475,0.695)	(0.54,0.79)	(0.2535,0.56)	(0.2535,0.435)
	(0.467,0.53)	(0.63,0.78)	(0.25,0)	

Table 3 shows that for each step, different actions by the black side will have different results, which means that the black side can take actions to maximize its responsiveness. For example, for the variances with a 0.5-unit advantage, the black side can choose to move a6, which gives the highest outcome. The games played, however, show indifference to each variation. A plausible explanation will be provided in the end.

4. Conclusion and discussion

As one of the oldest, most widely spread, and most influential chess styles, chess has rich cultural connotations. The fusion of competition, art, and science in international Go allows players to enhance their gaming skills and enrich their lives. From a technical perspective, artificial intelligence had already defeated humans on the stage of chess 20 years ago, but this has also brought new perspectives for humans to better understand chess. This article starts with online game data of human chess players and analyzes the impact of different variants of Sicilian defense on the victory rate. Past experiences have shown no significant difference between the main variations of the Sicilian Defense.

However, the analysis targets the Dragon Variation and filters out dominant strategies for the defending side. The limitations of this research and reasons why players didn't entirely depend on dominant strategies can be summarized into three points.

First, all data of forepassed games come from the Lichess website. Although players do not prefer different software, people in some regions may not prefer gaming online, leading to sample bias in winning rate selection. In addition, the website may not become popularized in some areas, resulting in data that is not representative enough. This may cause truly useful information to be obscured by noise. Hence, the conclusions do not apply to all games.

Secondly, from the perspective of chess, which is characterized by sequential moves. Neither perfect information form nor extensive form is flawless. The application of game theory, including removing strategies, might be affected.

Thirdly, although the Dragon Variation is the most well-known variation in the Sicilian Defense, which is representative of conducting investigations, it is undoubtedly a semi-closed type of gambit. Under this situation, even athletes would hold bias, such as not exchanging pawns or knights. Personal preferences might impact decisions, leading players to neglect dominant strategies and turn to closed ones. This means that even if there is a dominant strategy, due to the player's understanding of the game and biased decision-making, the dominant strategy will not be truly adopted in real matches.

To analyze the different deformations of Sicilian defense and the dragon variant further, a more robust analysis can be carried out by using more data to expand the sample size. Alternatively, it can be more convenient to use AI for calculation. Compared to network data, AI has two main advantages regarding calculation success rate. Firstly, AI has higher computing power for international chess than humans. Secondly, due to the matching mechanism in human games, the level of players on the website is uneven, with most of them having varying proficiency levels.

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