# The Superstar Effect: Evidence from Chess

## [PRELIMINARY DRAFT]

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**Abstract.** "Superstars" exist in many places – in classrooms, or in workplaces, there are a small number of people who show extraordinary talent and ability. The impact they have on their peers, however, is an ongoing research topic. In competition, they might intimidate others; causing their peers to show less effort. On the other hand, superstars might encourage higher effort, as their existence in a competition encourages them to "step up" their game. In this study, we analyze the impact of a superstar on their peers using evidence from chess. The existence of a contemporary superstar (and the current World Chess Champion) Magnus Carlsen, as well as, past world champions such as Garry Kasparov, Anatoly Karpov, or Bobby Fischer enables us to identify whether the existence of a superstar in a chess tournament has a positive or an adverse effect on other chess players' performance. The results indicate that the effect depends on the intensity of the superstar. If the skill gap between the superstar and the rest of the competitors is too large, there is evidence of an adverse effect. However, when the skill gap is small, there may be slight positive peer effects. In terms of head-to-head competition, the evidence shows that superstars outperform their opponents in all specifications due to their higher ability. Understanding the effect of superstars on peer performance is crucial for firms and managers considering to introduce a superstar associate for their team.

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# 1. Introduction

*"When you play against Bobby [Fischer], it is not a question of whether you win or lose. It is a question of whether you survive."*

–Boris Spassky, World Chess Champion, 1969 - 1972.

Maximizing their employees' effort is one of the chief goals of the firm. To this extent, firms typically encourage competition among their employees and allocate bonuses according to their performance and effort. At the same time, firms want to hire the best workers – preferably, the ones who are "superstars" in their fields. For this reason, it is not unusual to see million-dollar hiring contracts among the Forbes top 500 firms.

However, there might potentially be unintentional side effects of hiring a superstar employee. The seminal work done by Brown (2011) took a new and creative approach to analyze these potential side effects. She considered a famous superstar from golf: Tiger Woods. Her goal was to uncover whether Tiger Woods had any effect –adverse or positive– on his competitors' performance. She compared performances in tournaments with and without Tiger Woods and unveiled that there was a sharp decline in performance in tournaments in which Tiger Woods competed in. This evidence points out that Tiger Woods, as a superstar, creates a psychological pressure on his competitors which has a discouraging effect, causing them to perform worse than their typical performance.

In this study, we analyze the superstar effect using observations from chess. Employing a rich move-level dataset from 1962 to 2019, we study the impact of six different superstars in different time periods on tournament performance: Magnus Carlsen, Garry Kasparov, Anatoly Karpov, Bobby Fischer, Hou Yifan, and Igors Rausis. We find that a superstar lowers the performance in a tournament if there is a very large skill gap between the superstar and the competitors. This effect seems to be driven by the players' belief that their chances to win the tournament are slim. There appears to be a slight positive effect with superstar presence when the players believe they do have a chance to win the tournament. In terms of head-to-head competition, the effect is clear. For all samples, the superstar players strongly dominates their opponents, and some superstars are more dominating than others.

Chess provides a clean setting to analyze the superstar effect for the following reasons. First, non-player related factors are minimal to non-existent in chess since every chess board is the same for all players. Second, both game-level and move-level performance indicators can be obtained with the use of computer algorithms that can evaluate the quality of each move. Third, multiple chess superstars exist who lived in different time periods and come from different backgrounds, improving the external validity of the study.

The literature following Brown (2011) use alternative settings ranging from professional track and field competitions to swimming. A study in a similar spirit to Brown (2011) that also analyzes a superstar from golf is Tanaka and Ishino (2012). Their superstar is Masashi Ozaki from Japan who competed in Japan golf tour and dominated the tournaments he participated in throughout the 1990s. Their results are in parallel with Brown (2011): the presence of a superstar affects adversely the scores of the other players. Guryan et. al. (2009) is another study that focuses on the partners' performance. They measure how a golfer's performance is affected by their partner's performance and find that the partner's performance has very little impact on a player's own performance. This finding differs from previous studies focusing on peer effects in the workplace or in the classroom where typically positive peer effects exists. (Mas and Moretti, 2009; Duflo et. al., 2011; Cornelissen et. al., 2017)

Further work done by Hill (2014a) focuses on a different superstar: Usain Bolt. He compares the performance of athletes in a run where Usain Bolt is competing and where Usain Bolt is not present. His results are the opposite of the results in Brown (2011). Athletes perform much better when Usain Bolt is competing. This can be attributed to non-superstar athletes being motivated by having Usain Bolt running just "within their reach", enabling them to push one step further and show extra effort. Findings in Hill (2014b), focusing on track and field events are similar to those in Hill (2014a): higher performing athletes are creating a positive impact on their competitors' performance.

Swimming is used in Yamane and Hayashi (2015) and Jane (2015). Yamane and Hayashi (2015) compare performance of swimmers who compete in adjacent lanes and find that the performance of a swimmer is positively affected by the performance of the swimmer in the adjacent lane. In addition, this effect is amplified by the observability of the competitor's performance. Specifically, in backstroke competitions where observability of the adjacent lane is minimal, there appears to be no effect; whereas the effect exists in free-style competitions with higher observability. Jane (2015) uses data on swimming competitions in Taiwan and finds that having faster swimmers in a competition increases the overall performance of all the competitors participating in the competition. This finding agrees with Yamane and Hayashi (2015) and Hill (2014a, 2014b).

Connolly and Rendleman (2014) and Babington et. al. (2020) re-assess the findings in Brown (2011). Their evidence points out that an adverse superstar effect may not be as strong as suggested by in Brown (2011), and that the results from Brown (2011) are not robust to alternative specifications. They suggest that the effect could work in the opposite direction – that the top competitors can perhaps bring forth the best in other players' performance. In addition, Babington et. al. (2020) provide further evidence using observations from men's and women's FIS World Cup Alpine Skiing competitions and find little to no peer effects when skiing superstars Hermann Maier and Lindsey Vonn participate in a tournament.

Economic theory on contests suggests an adverse effect to exist when players with largely different abilities compete for a prize. The seminal work of Lazear and Rosen (1981) describes the incentive effects of heterogeneous players in rank-order tournaments. Baik (1994) and Nti (1999) analyze Tullock contests with two-players with different abilities and show a decrease in the equilibrium effort for the competitors as the relative ability difference increases. Brown (2011) provides a Tullock contest extended to n-players in which the players are adversely affected by the presence of a high ability superstar. Xiao (2020) shows the possibility of having a positive or a negative incentive effect when a superstar participates in a tournament. His work suggests the effect to depend on the prize structure, ability composition of the participants, and the level of difference between the ability types.

The rest of the paper is organized as follows: First, a two-player tournament model with heterogeneous ability and multiple prizes is presented in section 2. Section 3 gives background information on chess and describes how chess data is collected and analyzed. Section 4 provides the empirical design. Section 5 presents the results, and section 6 concludes.

## 2. Theory

Consider a two-player model in which a player competes against a superstar. We model such face-to-face competition as the following two-player contest. Player 1 maximizes his expected payoff

$$\max_{e_1} \quad \frac{e_1}{(e_1+\theta e_2)} V_1 - e_1$$

where $V_1$ is the prize (monetary or ELO points) which player 1 can win. Player 2, who is a superstar, has ability $\theta \geq 1$ and maximizes her expected payoff

$$\max_{e_2} \quad \frac{\theta e_2}{(e_1+\theta e_2)} V_2 - e_2$$

where $V_2$ is the prize which player 2 can win. The first order condition for player 1 is

$$\frac{\theta e_2}{(e_1+\theta e_2)^2}V_1 - 1 = 0,$$

and for player 2,

$$\frac{\theta e_1}{(e_1+\theta e_2)^2}V_2 - 1 = 0.$$

It must be true that in equilibrium

$$\frac{e_2}{e_1} = \frac{V_2}{V_1}$$

which yields the equilibrium effort level for player 1,

$$e_1^* = \frac{\theta V_1 V_2}{(V_1+\theta V_2)^2}V_1$$

and similarly for player 2,

$$e_2^* = \frac{\theta V_1 V_2}{(V_1+\theta V_2)^2}V_2.$$

The probability of success for player 1 in equilibrium is

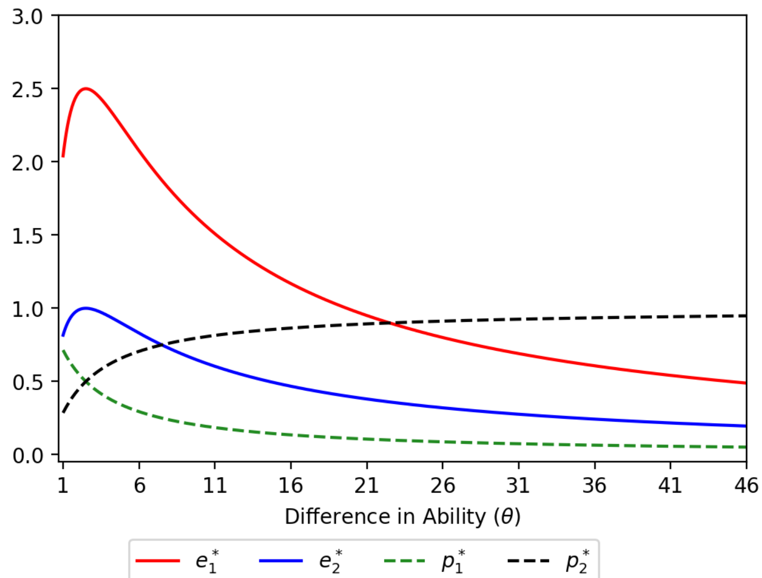
$$p_1^* = \frac{e_1^*}{e_1^*+\theta e_2^*} = \frac{1}{1+\theta\frac{V_2}{V_1}}$$

and for player 2,

$$p_2^* = \frac{\theta e_2^*}{e_1^*+\theta e_2^*} = \frac{1}{1+\frac{V_1}{\theta V_2}}.$$

Figure 1 shows how equilibrium efforts and win probabilities change for different levels of heterogeneity. Initially, when the ability difference is small, the effort level for both players increases. As the ability difference increases, players show less effort. In other words, if a superstar is "super", the model predicts an adverse effect, whereas if the gap between the superstar and the underdog is small, the effect is positive with both players showing higher effort.

**Figure 1:** Equilibrium effort and win probabilities with differences in ability




**Note:** Prizes are taken as $V_1 = 10$ and $V_2 = 4$ reflecting that the prize for a non-superstar player is greater than of the superstar's. By assuming $V_1 > V_2$, we assume the underdog to enjoy a greater benefit if he manages to win the competition against the superstar. This is also evident in chess: in ELO rating calculations, the lower rated player gains more rating points if he wins against a higher ranked player.

# 3. Data

## 3.1 Background for Chess

Chess is a two-player game with origins dating back to 6th century AD. Chess is played over a 8x8 board with 16 pieces for each side (8 pawns, 2 knights, 2 bishops, 2 rooks, 1 queen, and 1 king). Figure 2 shows a chess board. Players make moves in turns in which the player with the white pieces moves first. The ultimate goal of the game is to capture the enemy king. A player can get close to this goal by threatening the king through a "check": if the king has no escape, the game ends with a "checkmate". A game can end in three ways: white player wins, black player wins, or the game ends in a draw.

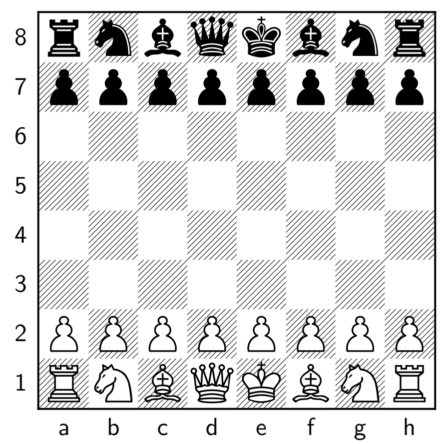



Figure 2: A chess board

The possible combinations of moves in a chess game is estimated to be more than the number of atoms in the universe.[1] However, some moves are better than others. With years of vigorous training, professional chess players learn how to find the best moves by typically employing backward-induction and calculating the consequences of each move to a certain complexity level. Failing to find the best moves in a position typically leads to the player losing their game at the top level. The player who performs better in general is the player who manages to find the correct moves more often.

Over the past decades, computer scientists have developed algorithms, or "chess engines" that exploit the game-tree structure of chess. These engines analyze each possible tree branch to come up with the best moves. The early chess

[1] A lower bound on the number of possible moves is $10^{120}$ moves, per Shannon (1950) while the number of atoms in the observable universe is estimated to be roughly $10^{80}$.

engines were inferior to humans. After a few decades however, one chess engine developed by IBM in the 1990s, Deep Blue, famously defeated the world chess champion at the time, Garry Kasparov in 1997. This was the first time a world chess champion lost to a chess engine under tournament conditions. Since then, chess engines have passed well beyond the human skill. As of 2020, Stockfish 11 is the strongest chess engine with an ELO rating of 3497.[2] In comparison, the current world chess champion, Magnus Carlsen, has an ELO rating of 2862.[3]

In addition to finding the best moves in a given position, a chess engine can be used to analyze the games played between human players.[4] Quality of a move can be measured numerically by evaluating the move chosen by a player and comparing it to the list of moves suggested by the chess engine. If the move played by a player is considered a bad move by the engine, then that move is assigned a negative value with its magnitude depending on the engine's evaluation.

### 3.2 Chess Superstars

The first official world chess champion is Wilhelm Steinitz who won the title in 1886. Since Steinitz, there have been fifteen world chess champions in total. Among these fifteen players, four of them have shown an extraordinary dominance over their peers: Magnus Carlsen, Garry Kasparov, Anatoly Karpov, and Bobby Fischer.

Magnus Carlsen is the current world chess champion who first became champion in 2013 at age 22. He reached the highest ELO rating ever achieved in history. Garry Kasparov was the world champion from 1985-2000 and was the number one ranked chess player for 255 months, setting a record for maintaining the number one position the longest duration of time. Anatoly Karpov was the world champion before Kasparov in the years 1975-1985. He won over 160 tournaments, which is a record for the highest number of tournaments won by a chess player. Lastly, Bobby Fischer was the world champion before Karpov between 1972-1975. He won all U.S. championships he played from 1957 (at age 14) to 1966, with a 11/11 score in the 1963 U.S. championship in which no other player in history has ever achieved a perfect score on a U.S. chess championship other than Fischer to this date.

[2]ELO rating, developed by Arpad ELO, is the standart measure for strength in chess. Modern chess engines, such as Stockfish, have much higher ELO ratings compared to humans. Most modern computers are strong enough to run Stockfish for analyzing chess positions and finding the best moves, which we use in our analyses.

[3]The highest ELO rating ever achieved by a human was 2882 in May 2014 by Magnus Carlsen.

[4]Every chess game played at the top-level is recorded, including all the moves played by the players.

In addition to male superstar world chess champions, there exists a female chess superstar: Hou Yifan, a four time women's world chess champion in the years between 2010-2017. She played three women's world chess championship matches and did not lose a single game against her opponents. She dominated the tournaments from 2014 until she decided to stop competing in women's tournaments and started to play solely in men's tournaments. Figures 3-12 show how the four world chess champions, Carlsen, Kasparov, Karpov and Hou Yifan performed compared to their peers across years.[5]

Lastly, we consider a chess grandmaster, Igors Rausis, who competed against non-masters in the years between 2012-2019. He was one of the top 100 chess players in the world at the time he competed in tournaments against players who had ELO ratings 500 points less than him. The ELO rating difference between him and the average opponent in the tournaments he competed in between these years is similar to Magnus Carlsen, with an ELO rating of 2882 competing against Stockfish 11 with an ELO rating 3497. Figure 13 shows the ELO rating distribution of such tournament. This creates a unique setting in which a very strong player plays in tournaments against much lower rated opponents.[6]

### 3.3 ChessBase Mega Database

Our data comes from the 2020 ChessBase Mega Database containing over 8 million chess games dating back to 1400s. Every chess game is contained in a pgn file with including information on the player names, player's side, ELO ratings, date and location of the game, tournament name, round, and the moves played. An example pgn file and a tournament table is provided in the appendix Table A2 and Figure A1, respectively. In a chess tournament, each move is recorded by the players, including the details about the players such as their names and their ELO ratings, as well as, game round, date, time and location. A copy of these records are then collected by the tournament organizers and stored for record-keeping. ChessBase collects these games from the organizers and makes them available for those would like to study and analyze the games for a fee. Table A1 in the appendix provides a summary of variables used and their definitions, and table 1 presents the summary statistics.

In total, our study analyzes over 2 million moves from approximately 30,000

[5]ELO rating information is not available for Fischer's era as FIDE started to began to use ELO ratings in 1970.

[6]Additionally, Igors Rausis was banned by FIDE, the International Chess Federation, in July 2019 due to cheating using a chess engine during tournaments.

games played in over 300 tournaments between 1962 and 2019.[7] Stockfish 11 is used for the analyses. For each move, the engine was given half a second. Figure 14 shows an example of how a game was analyzed. In the game, the player with the white pieces initially gains an advantage, and loses the advantage towards the end of the game by making moves that are considered bad by the chess engine. The engine analyzes each of the 162 moves played in the game, and evaluates the quality of each move.

### 3.4 Measuring Performance

We use two methods to assess a player's performance in a tournament. The first is the metric named Average Centipawn Loss (ACPL) using move-level information. This method employs the use of a chess engine with its methods discussed in the previous section. ACPL is the average of all the penalties a player is assigned to by the chess engine for the bad moves they made in a game. If the player plays the best moves in a game, his ACPL will be small− a smaller number means the player performed better. On the other hand, if the player makes moves that are considered bad by the engine, the player's ACPL score would be higher.

The second method we use employs game-level outcomes. Every chess game ends in a win, a loss, or a draw. The player who wins a tournament is the one who has more wins and fewer losses, as the winner of a game receives a full point towards his tournament score.[8] Thus a player who has more wins in a tournament shows higher performance. In terms of losses, the opposite is true. If a player had too many losses in a tournament, their chances to win the tournament would be slim. Lastly, a draw is considered better than a loss and worse than a win against opponents with similar ELO ratings.

## 4. Empirical Design

The baseline model compares a player's performance in a tournament where a superstar is present with a tournament where there is no superstar competing. This can be captured by the following,

$$\begin{aligned} Performance_{i,j} = \beta_0 + \beta_1 Superstar_j \times HighELO_{i,j} + \beta_2 Superstar_j \times MidELO_{i,j} \\ + \beta_3 Superstar_j \times LowELO_{i,j} + \beta_4 HighELO_{i,j} + \beta_5 MidELO_{i,j} \\ + \boldsymbol{\Theta X_{i,j}} + \eta_i + \epsilon_{i,j} \quad (1) \end{aligned}$$

[7] A list of the tournaments is provided in the appendix.

[8] A draw brings half a point, a loss brings no points in a tournament.

where $Performance_{i,j}$ is the performance of player $i$ in tournament $j$, measured by methods discussed in section 3.4. $Superstar_j$ is an indicator for superstar being present in tournament $j$. $\epsilon_{i,j}$ is an idiosyncratic shock. Having negative signs for $\beta_1$-$\beta_3$ would mean the presence of a superstar creates an adverse effect, creating a disincentive for players to show effort resulting in worse performance outcomes. $HighELO_{i,j}$ equals one if the player has an ELO rating on the first quartile in the ELO rating distribution of the tournament participants. $MidELO_{i,j}$ captures the second and third quartiles, and $LowELO_{i,j}$ captures the bottom quartile. $\boldsymbol{\Theta X_{i,j}}$ contains the game and tournament level controls. In addition to tournament level specifications, chess allows for a game level analysis which can be specified as the following,

$$Performance_{i,j,k} = \alpha_0 + \alpha_1 AgainstSuperstar_{i,j,k} + \boldsymbol{\Phi X_{i,j}} + \eta_i + \epsilon_{i,j,k} \tag{2}$$

where $AgainstSuperstar_{i,j,k}$ equals one if player $i$ in tournament $j$ plays against a superstar in round $k$. In this specification, $\alpha_1$ captures the effect of head-to-head competition against a superstar.

In terms of which tournaments to join, chess superstars typically consider their schedule. They play in the strongest tournaments; however it is typically not possible for them to play in all top-level tournaments since it would be difficult for them to prepare for a large number of tournaments in a year.[9] Generally, if they play a world championship match in a given year, they tend to play in fewer tournaments in that year to be able to better prepare for the world championship match. In the years without a world championship match, they typically pick a certain number of tournaments to participate in. They may very well play in fewer tournaments in a given year if they think their schedule does not allow for adequate preparation for each tournament.

## 5. Results

Table 2 shows the performance of non-superstar players playing against a superstar for each sample. There is a distinct pattern that is true for all superstars: playing against them is associated with a higher ACPL score, lower chances to win, and higher chances to lose. This finding verifies that the superstars considered in our study are indeed dominating and show greater performance compared to their peers. For instance, a player who plays against Fischer shows

[9] In our sample, a tournament with a superstar on average has 50 points higher average ELO score compared to the tournaments without a superstar. This shows that chess superstars indeed play in the strongest tournaments.

5.76 points higher ACPL compared to his games against other players. His likelihood of win is 35.9% less; for a draw, 13.9% less; and for a loss 35.9% higher compared to his typical games. This implies that in terms of direct competition, these superstars had a strong dominance over their peers. The strongest domination appears to be with Rausis and Hou Yifan, followed by Fischer as the the magnitudes for ACPL, win, and loss probabilities are stronger compared to the rest of the samples.

The following set of tables, tables 3-10, show the effect of a superstar's presence on the performance of other competitors. It appears that the most dominant superstar according to Table 2, Rausis, had an adverse effect on the top players' performance. These players had a 7.23 higher ACPL score, 15 percentage points less winning chances, 31 percentage points less draws, and a 46 percentage points higher loss rate, although the coefficient on the ACPL and win rate is imprecise. A similar adverse effect is true for the second most dominant superstar, Hou Yifan. Her presence is associated with a 5.50 points of higher ACPL, 6.7 percentage points winning chances and a 10 percentage points higher loss rate for the top players in a tournament. For Fischer, the coefficient for ACPL is negative and imprecise. It appears that the top players did not make more mistakes when Fischer was present. However they indeed had fewer wins and more draws.

Another situation with intense competition is when two superstars, Kasparov and Karpov both participated in a tournament. This means that for a given player, he will have to face both Kasparov and Karpov and perform better than both of them in order to win a tournament. This tough competition appears to create an adverse effect on players. Top players had a 3.5 points higher ACPL, 10 percentage points less win rate, and a 16 percentage points higher loss rate.

The next set of results shows that Kasparov and Karpov's presence separately does not appear to create an adverse effect for the top players. For Kasparov, the effect on the top players appears to be positive, although the coefficients are again imprecise. However, bottom players were negatively affected by his presence. They had 2.29 higher ACPL points, 8 percentage points less win rate, and a 6 percentage points higher loss rate. For Karpov, top players appear to show a slight worse performance, however the coefficients are not significant. Lastly, Carlsen had the least dominance compared to the rest of the superstars in our study according to Table 2. His presence appears to create a positive effect on performance. Players played more accurately and made fewer mistakes. For instance, top players had on average 2 points lower ACPL score. The positive effect appears to apply for all the tournament participants.[10]

## 6. Conclusion

Theory predicts an adverse effect to exist in tournaments where a highly skilled competitor is present. Considering their chances to win a tournament against a "superstar", the competitors are discouraged, thus their effort level goes down. On the other hand, if the superstar is only slightly better than the rest of the group, theory predicts that players will show higher effort, as they will have higher chances to win the tournament and win the prize.

Using evidence from chess, we empirically show an adverse effect to exist when a "super" superstar is present in a tournament. Players make more mistakes, win fewer games and lose more games when they compete in a tournament with an extremely highly skilled superstar. In terms of head-to-head competition, our findings are consistent with the theory. A superstar shows greater skill, has higher chances for a win, and lower chances to lose against their opponents. However, when a superstar is not "super", there is suggestive evidence for a slight positive effect, even though these superstars still show better performance in head-to-head competition. In these tournaments, players "step-up" their game and collectively show greater performance.

The literature analyzing the superstar effect shows mixed empirical evidence. In golf, the effort level decreases with superstar presence; in 100-metres running or swimming contests, the effort level appears to increase. In this paper, we show that the effect depends on the intensity of the superstar against the rest of the competitors. An intense superstar creates an adverse effect in tournaments while a superstar who is only slightly more skilled than the rest of the competitors may have a positive impact on the effort level in a tournament.

The takeaway for firms seeking to hire a superstar employee is that hiring a superstar employee may create a positive or an adverse effect on the cohort's performance depending on the skill level gap. If the gap is too large, there may be negative side effects of hiring a superstar employee. In these settings, a highly skilled team member would destroy competition and create an adverse effect on the rest of the team members.

[10]Carlsen's sample is the only sample in which the draw rates are higher and ACPL scores are smaller. Many chess fans criticize modern chess to have too many draws, which is evident in our analyses.

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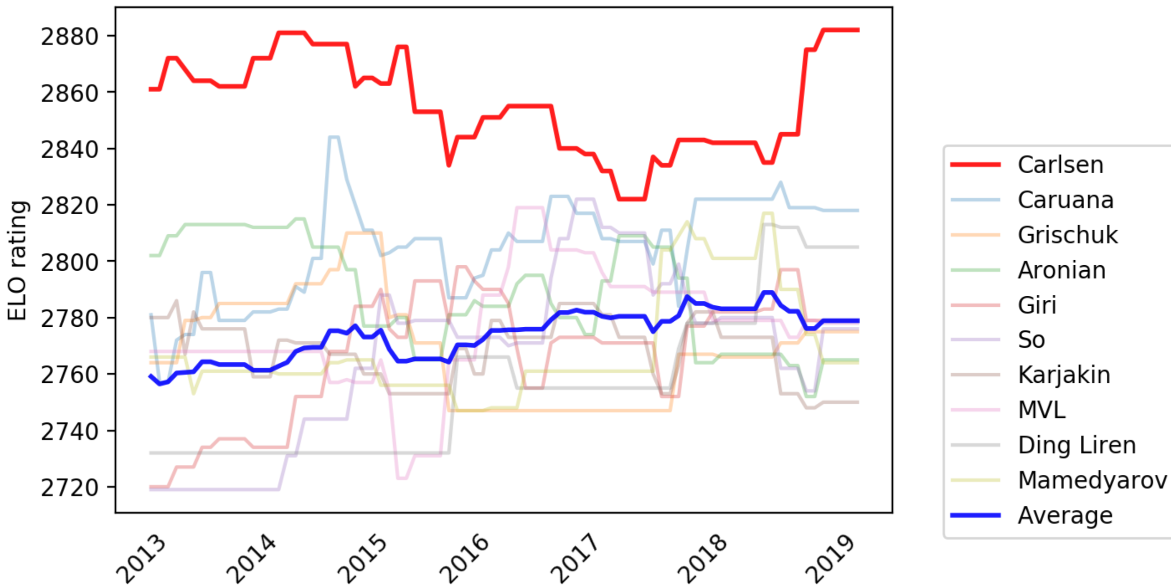
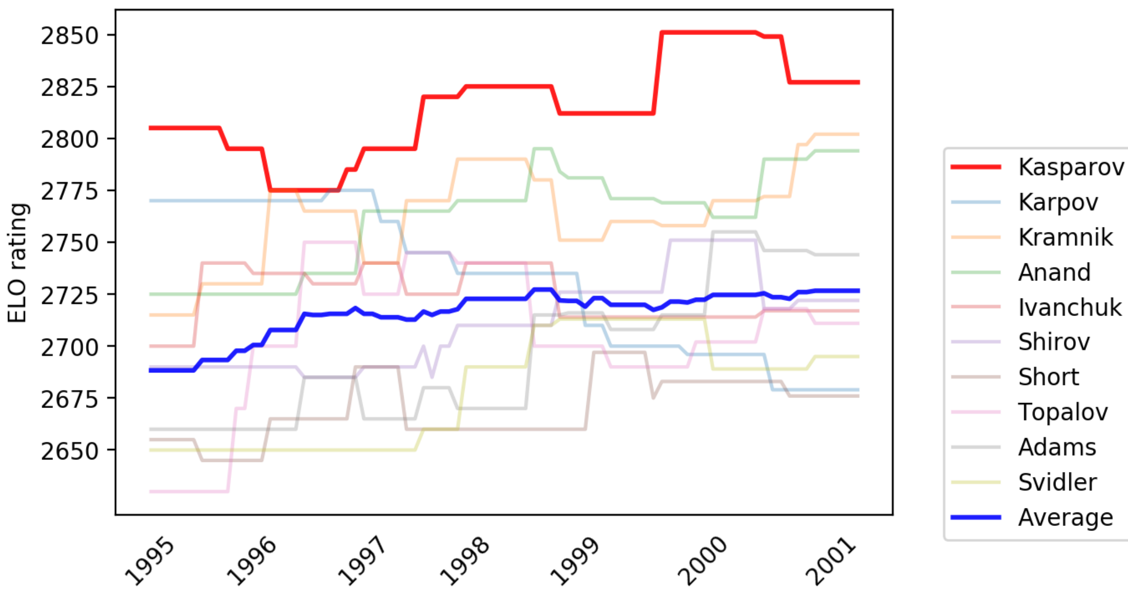
## Tables & Figures

**Figure 3:** ELO ratings of top chess players between 2013-2019.



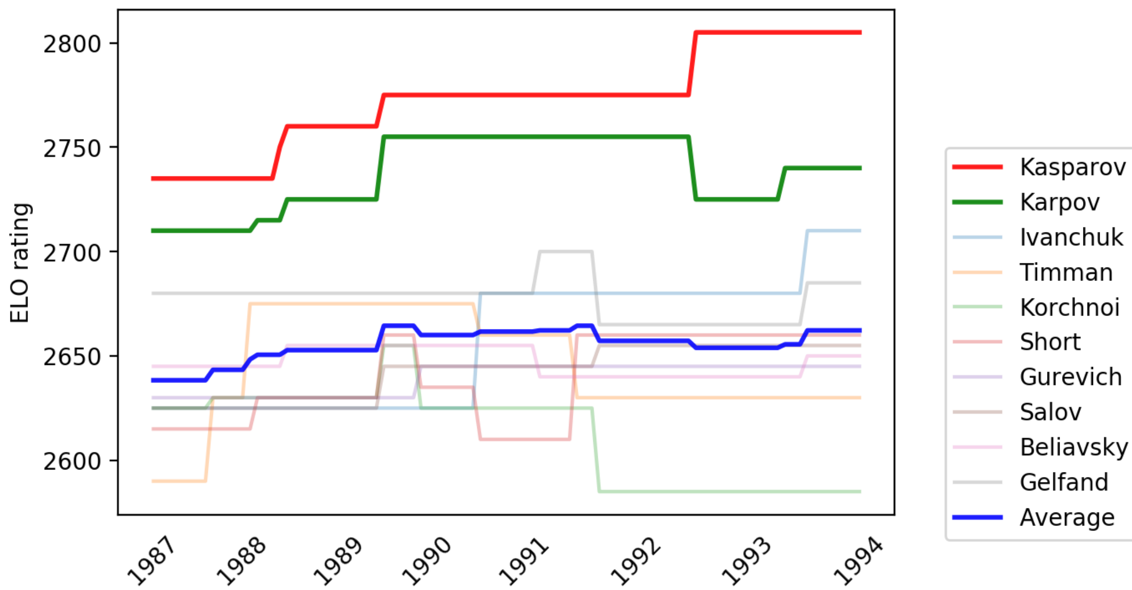

**Note:** The blue line shows the average ELO rating of top chess players other than Carlsen (World ranking 2−10). ELO rating data is obtained from Chessbase Mega Database 2020.

**Figure 4:** ELO ratings of top chess players between 1995-2001.



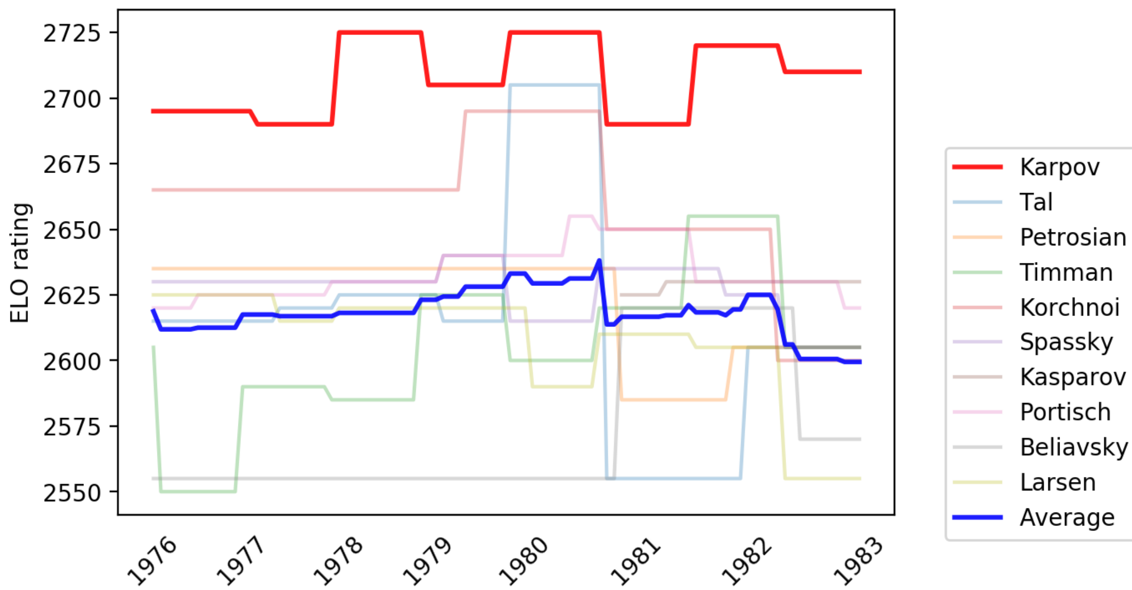

**Note:** ELO rating data is obtained from Chessbase Mega Database 2020.

**Figure 5:** ELO ratings of top chess players between 1987-1994.



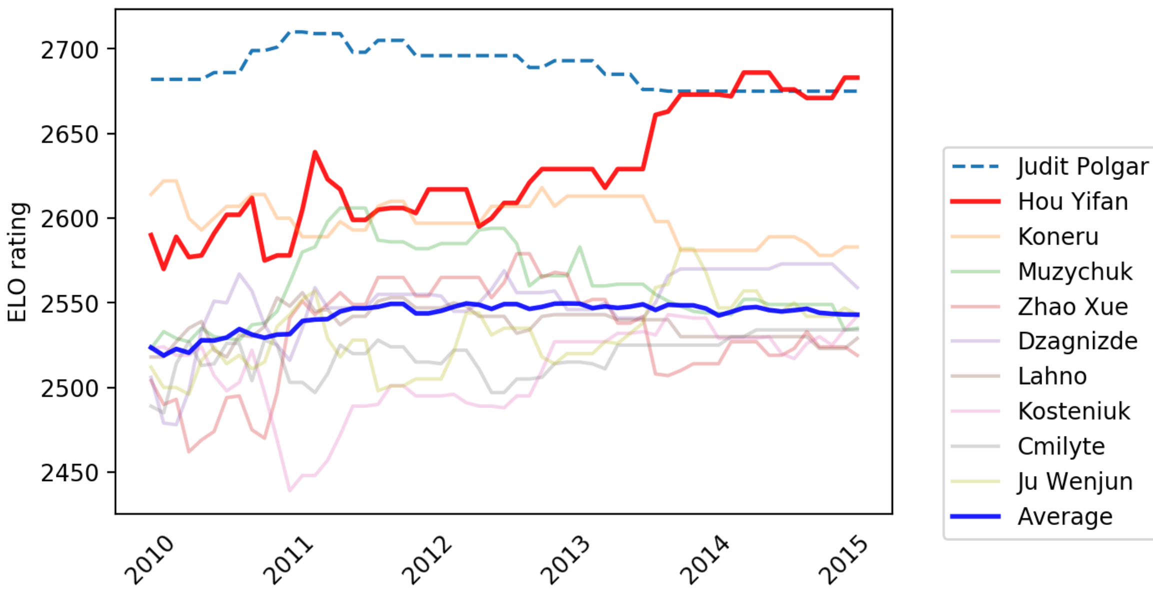

**Note:** ELO rating data is obtained from Chessbase Mega Database 2020.

**Figure 6:** ELO ratings of top chess players between 1976-1983.



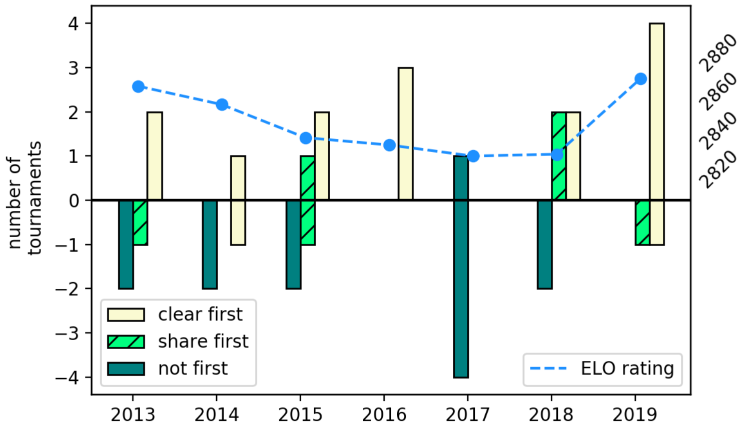

**Note:** ELO rating data is obtained from Chessbase Mega Database 2020.

**Figure 7:** ELO ratings of top female chess players between 2010-2015.



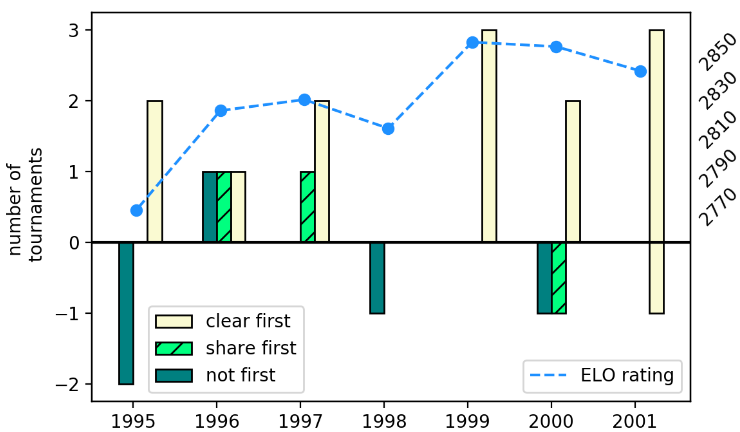

**Note:** Judit Polgar is considered the strongest female chess player of all time, however she stopped competing in female tournaments in 1990 when she was 14 years old. Hou Yifan stopped competing in female tournaments after 2015. ELO rating data is obtained from FIDE available online at https://ratings.fide.com

**Figure 8:** Carlsen's tournament performance (classical)



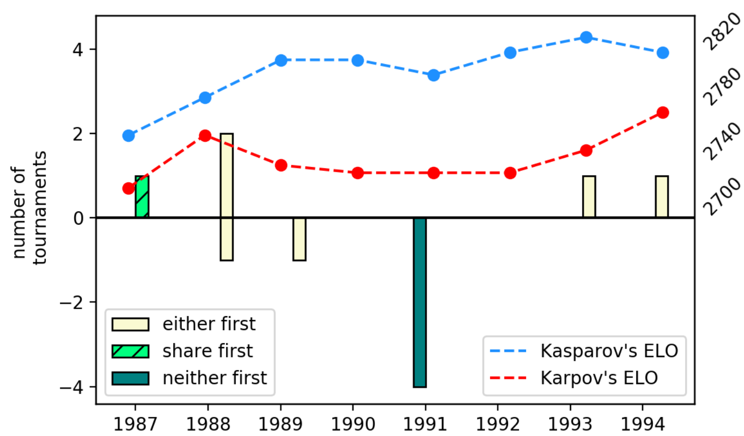

**Note:** Carlsen's ELO rating data is obtained from FIDE.

**Figure 9:** Kasparov's tournament performance (classical)



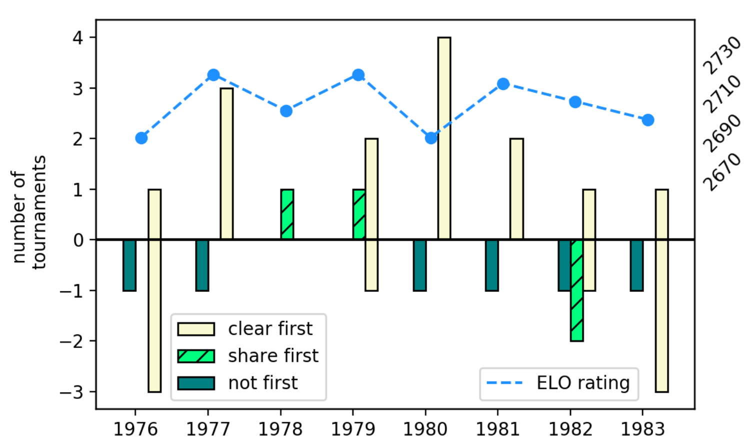

**Note:** Kasparov's ELO rating data is obtained from Chessbase Mega Database 2020.

**Figure 10:** Kasparov and Karpov's tournament performance (classical)



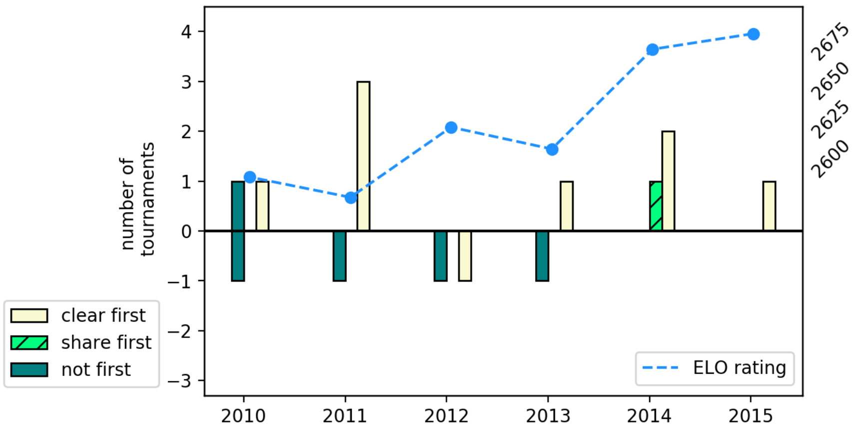

**Note:** Kasparov's and Karpov's ELO rating data is obtained from Chessbase Mega Database 2020.

**Figure 11:** Karpov's tournament performance (classical)



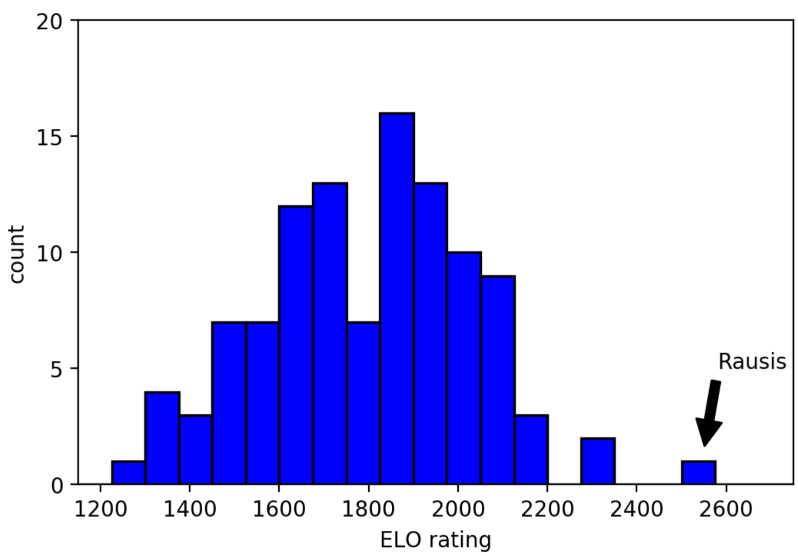

**Note:** Karpov's ELO rating data is obtained from Chessbase Mega Database 2020.

**Figure 12:** Hou Yifan's tournament performance (classical)



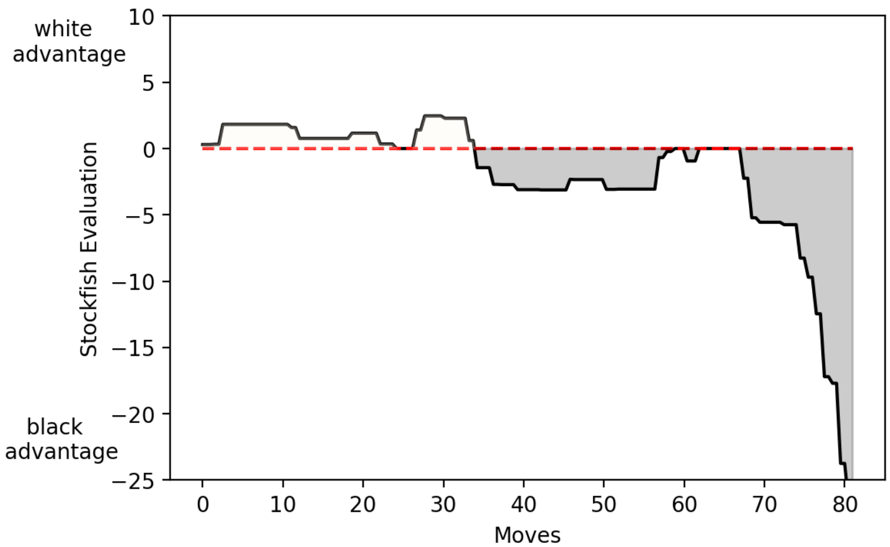

**Note:** Hou Yifan's ELO rating data is obtained from Chessbase Mega Database 2020.

**Figure 13:** Elo rating distribution of a tournament Rausis competed in 2012.




**Note:** The tournament is Tres Cantos Open played in June 2012 in Spain. Rausis had an ELO rating of 2514. His nine opponents had an average ELO rating of 2046. ELO rating information is obtained from Chessbase Mega Database 2020.

**Figure 14:** Computer evaluation of a game played by Carlsen in 2019.




**Note:** The game is played between Vincent Keymer (White) and Magnus Carlsen (Black) on April 20, 2019 during the first round of Grenke Chess Classic 2019. Keymer's ACPL was 21.82 and Carlsen's 5.77 using our algorithm. The chess engine used for evaluations is Stockfish 11.

**Table 1:** Summary statistics for all samples.

| | *years: 2013-2019* | | | | *years: 1995-2001* | | | |
|---|---|---|---|---|---|---|---|---|
| | *with Carlsen* | | *without Carlsen* | | *with Kasparov* | | *without Kasparov* | |
| variable | mean | sd | mean | sd | mean | sd | mean | sd |
| ACPL | 7.337 | 14.635 | 8.033 | 14.659 | 8.927 | 12.416 | 9.625 | 17.833 |
| win | .173 | .378 | .203 | .402 | .229 | .420 | .230 | .420 |
| draw | .652 | .476 | .592 | .491 | .548 | .497 | .539 | .498 |
| loss | .173 | .378 | .203 | .402 | .221 | .415 | .230 | .420 |
| ELO | 2759 | 47.10 | 2714 | 80.46 | 2685 | 59.56 | 2644 | 64.73 |
| Moves | 43.56 | 15.68 | 45.75 | 17.64 | 39.03 | 16.01 | 39.48 | 15.74 |
| *#of tournaments* | =35 | | =40 | | =22 | | =44 | |
| *#of games* | =1,328 | | =1,762 | | =818 | | =1,970 | |
| *#of moves* | =115,498 | | =160,776 | | =63,866 | | =154,852 | |

| | *years: 1987-1994* | | | | *years: 1976-1983* | | | |
|---|---|---|---|---|---|---|---|---|
| | *with Kasparov & Karpov* | | *without Kasparov & Karpov* | | *with Karpov* | | *without Karpov* | |
| ACPL | 9.722 | 16.448 | 9.614 | 16.805 | 8.540 | 13.613 | 9.370 | 17.913 |
| win | .218 | .413 | .236 | .424 | .226 | .418 | .259 | .438 |
| draw | .563 | .496 | .527 | .499 | .566 | .495 | .505 | .500 |
| loss | .218 | .413 | .236 | .424 | .207 | .405 | .235 | .424 |
| ELO | 2624 | 56.46 | 2586 | 55.68 | 2558 | 67.85 | 2530 | 76.21 |
| Moves | 39.90 | 16.84 | 40.20 | 16.77 | 37.17 | 17.65 | 38.04 | 17.20 |
| *#of tournaments* | =11 | | =37 | | =32 | | =34 | |
| *#of games* | =813 | | =1,787 | | =1,972 | | =3,114 | |
| *#of moves* | =63,345 | | =143,164 | | =146,966 | | =236,392 | |

| | *years: 1962-1970* | | | | *years: 2014-2019* | | | |
|---|---|---|---|---|---|---|---|---|
| | *with Fischer* | | *without Fischer* | | *with Hou Yifan* | | *without Hou Yifan* | |
| ACPL | 9.987 | 19.134 | 10.238 | 17.402 | 8.581 | 21.582 | 9.144 | 23.095 |
| win | .254 | .435 | .249 | .432 | .261 | .439 | .242 | .429 |
| draw | .490 | .499 | .500 | .500 | .477 | .499 | .514 | .500 |
| loss | .254 | .435 | .249 | .432 | .261 | .439 | .242 | .429 |
| ELO* | - | - | - | - | 2492 | 67.88 | 2502 | 41.82 |
| Moves | 38.36 | 16.55 | 36.63 | 15.64 | 45.83 | 18.60 | 47.33 | 17.62 |
| *#of tournaments* | =16 | | =81 | | =4 | | =6 | |
| *#of games* | =1,762 | | =7,652 | | =276 | | =300 | |
| *#of moves* | =134,430 | | =559,038 | | =25,168 | | =28,220 | |

| | *years: 2012-2019* | | | |
|---|---|---|---|---|
| | *with Rausis* | | *without Rausis* | |
| ACPL | 15.390 | 28.487 | 14.731 | 27.857 |
| win | .405 | .491 | .365 | .481 |
| draw | .213 | .409 | .275 | .446 |
| loss | .380 | .485 | .359 | .479 |
| ELO | 1979 | 275.21 | 2052 | 259.98 |
| Moves | 38.34 | 14.93 | 38.69 | 15.87 |
| *#of tournaments* | =8 | | =30 | |
| *#of games* | =1,016 | | =2,818 | |
| *#of moves* | =76,912 | | =216,046 | |

**Notes:** Superstar player observations are exluded in each sample. Data comes from Chessbase Mega Database 2020.

∗: ELO rating system was first adopted by FIDE beginning 1970.

**Table 2:** Performance against a superstar.

| | *Panel A. Classical* | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | | |
| | *ACPL* | *win* | *draw* | *loss* | *# of games* | *# of moves* |
| Against Carlsen | 3.957*** | -0.112*** | -0.0618** | 0.173*** | 1,722 | 153,283 |
| *2013-2019* | (0.895) | (0.0159) | (0.0282) | (0.0251) | | |
| Against Kasparov | 3.083*** | -0.171*** | -0.0292 | 0.201*** | 1,058 | 82,130 |
| *1995-2001* | (1.002) | (0.0201) | (0.0352) | (0.0338) | | |
| Against Kasparov or Karpov | 3.656*** | -0.182*** | -0.0424 | 0.224*** | 2,892 | 232,709 |
| *1987-1994* | (0.722) | (0.0192) | (0.0292) | (0.0285) | | |
| Against Karpov | 3.704*** | -0.179*** | -0.0345 | 0.213*** | 5,025 | 412,618 |
| *1976-1983* | (0.929) | (0.0155) | (0.0277) | (0.0275) | | |
| Against Fischer | 5.760*** | -0.220*** | -0.139*** | 0.359*** | 9,395 | 712,324 |
| *1962-1970* | (1.120) | (0.0307) | (0.0308) | (0.0425) | | |
| Against Hou Yifan | 7.050** | -0.259*** | -0.128*** | 0.387*** | 620 | 57,234 |
| *2014-2019* | (2.340) | (0.0146) | (0.0351) | (0.0250) | | |
| Against Rausis | 11.136*** | -0.670*** | -0.015 | 0.585*** | 7,563 | 296,808 |
| *2012-2019* | (1.299) | (0.0204) | (0.0688) | (0.0729) | | |

**Notes:** All regressions include player and year fixed effects, round fixed effects, event site fixed effects, average ELO in a tournament, player's side (white or black), and number of moves played. Clustered standard errors (clustered by tournament) are shown in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

**Table 3:** Performance in tournaments with and without Rausis.

| | *Panel A. Classical* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | *ACPL* | *win* | *draw* | *loss* |
| Superstar effect for | | | | |
| All players | -0.646 | -0.0105 | 0.0407 | -0.0302 |
| | (1.561) | (0.0516) | (0.0248) | (0.0494) |
| Top players$^{+}$ | 7.239 | -0.153 | -0.309$^{**}$ | 0.463$^{*}$ |
| | (7.568) | (0.143) | (0.144) | (0.231) |
| Last 2 rounds | 1.268 | -0.377$^{***}$ | 0.0534 | 0.324$^{**}$ |
| | (5.053) | (0.120) | (0.0651) | (0.135) |
| *Number of moves* | 292,958 | 292,958 | 292,958 | 292,958 |
| *Number of games* | 7,459 | 7,459 | 7,459 | 7,459 |

**Notes:** Rausis' games are excluded. The sample consists of open tournaments in Swiss system as opposed to the previous tables in which the samples consist of invitation-based Round robin tournaments. All regressions include player fixed effects, year fixed effects, month fixed effects, event site fixed effects, player's side (white or black), and number of moves played. Clustered standard errors (clustered by tournament) are shown in parentheses.

$^{+}$: These are the players with the top 2 highest ELO rating in a given tournament following Rausis' ELO rating.

$^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Table 4:** Performance in tournaments with and without Hou Yifan.

| | *Panel A. Classical* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | *ACPL* | *win* | *draw* | *loss* |
| Superstar effect for | | | | |
| Top 25% players | 5.500** | -0.0671 | -0.0336 | 0.101* |
| | (1.912) | (0.0691) | (0.0561) | (0.0470) |
| Mid 50% players | 0.701 | 0.0121 | 0.00655 | -0.0187 |
| | (2.049) | (0.0562) | (0.0600) | (0.0474) |
| Bottom 25% players | 3.908 | 0.0222 | -0.0560 | 0.0338 |
| | (3.077) | (0.0979) | (0.0616) | (0.0776) |
| *Number of moves* | 53,388 | 53,388 | 53,388 | 53,388 |
| *Number of games* | 577 | 577 | 577 | 577 |

**Notes:** Hou Yifan's games are excluded. All regressions include player fixed effects, year fixed effects, player's side (white or black), and number of moves played. Clustered standard errors (clustered by tournament) are shown in parentheses.
$^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Table 5:** Performance in tournaments with and without Fischer.

| | *Panel A. Classical* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | *ACPL* | *win* | *draw* | *loss* |
| Superstar effect for | | | | |
| All players | -0.344 | -0.0194 | 0.00753 | 0.0118 |
| | (0.513) | (0.0153) | (0.0155) | (0.0180) |
| Top players | -0.0540 | -0.123*** | 0.113*** | 0.00995 |
| | (0.792) | (0.0311) | (0.0320) | (0.0248) |
| *Number of moves* | 690,950 | 690,950 | 690,950 | 690,950 |
| *Number of games* | 9,395 | 9,395 | 9,395 | 9,395 |

**Notes:** Fischer's games are excluded. Top 10 players are the top chess players in the world from 1962-1970 other than Fischer.[+] All regressions include player fixed effects, year fixed effects, round fixed effects, event site fixed effects, player's side (white or black), and number of moves played. Clustered standard errors (clustered by tournament) are shown in parentheses.
[+]: These players are Tigran Petrosian, Viktor Korchnoi, Boris Spassky, Vasily Smyslov, Mikhail Tal, Mikhail Botvinnik, Paul Keres, Efim Geller, David Bronstein, and Samuel Reshevsky.
$^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Table 6:** Performance in tournaments with and without Kasparov & Karpov.

| | *Panel A. Classical* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | *ACPL* | *win* | *draw* | *loss* |
| Superstar effect *when both present* | | | | |
| Top 25% players | 3.554** | -0.106*** | -0.0533 | 0.159*** |
| | (1.374) | (0.0242) | (0.0416) | (0.0469) |
| Mid 50% players | 1.884 | -0.0184 | -0.0298 | 0.0483 |
| | (1.239) | (0.0331) | (0.0357) | (0.0315) |
| Bottom 25% players | 1.998** | -0.0465* | 0.0241 | 0.0224 |
| | (0.875) | (0.0254) | (0.0360) | (0.0286) |
| *Number of moves* | 156,507 | 156,507 | 156,507 | 156,507 |
| *Number of games* | 2,166 | 2,166 | 2,166 | 2,166 |

**Notes:** Kasparov and Karpov's games are excluded. Top 25% is defined as having an ELO rating in the top 25% among the competitors at the time of the tournament. Bottom 25% is defined as having an ELO in the bottom quartile. All regressions include player fixed effects, year fixed effects, round fixed effects, event site fixed effects, average ELO in a tournament, player's side (white or black), and number of moves played. Clustered standard errors (clustered by tournament) are shown in parentheses.
$^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Table 7:** Performance in tournaments with and without Kasparov.

| | *Panel A. Classical* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | *ACPL* | *win* | *draw* | *loss* |
| Superstar effect for | | | | |
| Top 25% players | -0.861 | 0.00970 | -0.0140 | 0.00431 |
| | (1.102) | (0.0385) | (0.0391) | (0.0299) |
| Mid 50% players | 0.271 | -0.0162 | -0.0145 | 0.0307 |
| | (0.879) | (0.0231) | (0.0328) | (0.0257) |
| Bottom 25% players | 2.229* | -0.0805** | 0.0133 | 0.0672** |
| | (1.239) | (0.0388) | (0.0385) | (0.0318) |
| *Number of moves* | 218,718 | 218,718 | 218,718 | 218,718 |
| *Number of games* | 2,292 | 2,292 | 2,292 | 2,292 |

**Notes:** Kasparov's games are excluded. Top 25% is defined as having an ELO rating in the top 25% among the competitors at the time of the tournament. Bottom 25% is defined as having an ELO in the bottom quartile. All regressions include player by year fixed effects, round fixed effects, event site fixed effects, average ELO in a tournament, player's side (white or black), and number of moves played. Clustered standard errors (clustered by player-year) are shown in parentheses.
$^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Table 8:** Performance in tournaments with and without Karpov.

| | *Panel A. Classical* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | *ACPL* | *win* | *draw* | *loss* |
| Superstar effect for | | | | |
| Top 25% players | -0.109 | -0.00403 | -0.0151 | 0.0191 |
| | (1.035) | (0.0408) | (0.0379) | (0.0313) |
| Med 50% players | 0.867 | 0.00709 | -0.00326 | -0.00383 |
| | (0.896) | (0.0269) | (0.0312) | (0.0270) |
| Bottom 25% players | 0.713 | -0.00470 | 0.0555 | -0.0508 |
| | (1.500) | (0.0466) | (0.0451) | (0.0428) |
| *Number of moves* | 385,060 | 385,060 | 385,060 | 385,060 |
| *Number of games* | 5,106 | 5,106 | 5,106 | 5,106 |

**Notes:** Karpov's games are excluded. Top 25% is defined as having an ELO rating in the top 25% among the competitors at the time of the tournament. Bottom 25% is defined as having an ELO in the bottom quartile. All regressions include player by year fixed effects, round fixed effects, event site fixed effects, average ELO in a tournament, player's side (white or black), and number of moves played. Clustered standard errors (clustered by player-year) are shown in parentheses.
$^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Table 9:** Performance in tournaments with and without Carlsen.

| | *Panel A. Classical* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | *ACPL* | *win* | *draw* | *loss* |
| Superstar effect for | | | | |
| Top 25% players | -2.043$^{**}$ | -0.0407 | 0.0777 | -0.0370 |
| | (0.999) | (0.0412) | (0.0531) | (0.0328) |
| Mid 50% players | -1.662$^{**}$ | -0.0273 | 0.0791$^{**}$ | -0.0518$^{*}$ |
| | (0.719) | (0.0341) | (0.0382) | (0.0291) |
| Bottom 25% players | -1.440 | -0.0429 | 0.0825 | -0.0396 |
| | (1.053) | (0.0403) | (0.0556) | (0.0424) |
| *Number of moves* | 276,272 | 276,272 | 276,272 | 276,272 |
| *Number of games* | 3,090 | 3,090 | 3,090 | 3,090 |

**Notes:** Carlsen's games are excluded. Top 25% is defined as having an ELO rating in the top 25% among the competitors at the time of the tournament. Bottom 25% is defined as having an ELO in the bottom quartile. All regressions include player by year fixed effects, month fixed effects, round fixed effects, event site fixed effects, average ELO in a tournament, player's side (white or black), and number of moves played. Clustered standard errors (clustered by player-year) are shown in parentheses.
$^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Table 10:** Performance in tournaments with and without a Superstar (overall effect).

| | *Panel A. Classical* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | *ACPL* | *win* | *draw* | *loss* |
| Superstar effect for | | | | |
| Top 25% players | 0.766$^{**}$ | -0.0311$^{**}$ | -0.0102 | 0.0413$^{***}$ |
| | (0.377) | (0.0140) | (0.0148) | (0.0139) |
| Mid 50% players | 0.107 | 0.00495 | -0.0164 | 0.0115 |
| | (0.300) | (0.00986) | (0.0125) | (0.0101) |
| Bottom 25% players | 0.305 | -0.0124 | 0.0218 | -0.00946 |
| | (0.459) | (0.0110) | (0.0148) | (0.0144) |
| *Number of moves* | 1,149,398 | 1,149,398 | 1,149,398 | 1,149,398 |
| *Number of games* | 13,228 | 13,228 | 13,228 | 13,228 |

**Notes:** Superstars' games, and Rausis' and Fischer's samples are excluded. Top 25% is defined as having an ELO rating in the top 25% among the competitors at the time of the tournament. Bottom 25% is defined as having an ELO in the bottom quartile. All regressions include player and year fixed effects, month fixed effects, round fixed effects, event site fixed effects, average ELO in a tournament, player's side (white or black), and number of moves played. Clustered standard errors (clustered by tournament) are shown in parentheses.
$^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Table 11:** Performance in tournaments with and without a superstar for top players.

| | (1) ACPL | (2) win | (3) draw | (4) loss | # of games | # of moves |
|---|---|---|---|---|---|---|
| Rausis present$^{+}$ | 7.239 | -0.153 | -0.309$^{**}$ | 0.463$^{*}$ | 7,459 | 292,958 |
| *2012-2019* | (7.568) | (0.143) | (0.144) | (0.231) | | |
| Hou Yifan present | 5.500$^{**}$ | -0.0671 | -0.0336 | 0.101$^{*}$ | 577 | 53,388 |
| *2014-2019* | (1.912) | (0.0691) | (0.0561) | (0.0470) | | |
| Fischer present$^{++}$ | -0.0540 | -0.123$^{***}$ | 0.113$^{***}$ | 0.00995 | 9,395 | 690,950 |
| *1962-1970* | (0.792) | (0.0311) | (0.0320) | (0.0248) | | |
| Kasparov & Karpov present | 3.554$^{**}$ | -0.106$^{***}$ | -0.0533 | 0.159$^{***}$ | 2,166 | 156,507 |
| *1987-1994* | (1.374) | (0.0242) | (0.0416) | (0.0469) | | |
| Kasparov present | -0.861 | 0.00970 | -0.0140 | 0.00431 | 2,292 | 218,718 |
| *1995-2001* | (1.102) | (0.0385) | (0.0391) | (0.0299) | | |
| Karpov present | -0.109 | -0.00403 | -0.0151 | 0.0191 | 5,106 | 385,060 |
| *1976-1983* | (1.035) | (0.0408) | (0.0379) | (0.0313) | | |
| Carlsen present | -2.043$^{**}$ | -0.0407 | 0.0777 | -0.0370 | 3,090 | 276,272 |
| *2013-2019* | (0.999) | (0.0412) | (0.0531) | (0.0328) | | |
| Aggregate effect$^{+++}$ | 0.766$^{**}$ | -0.0311$^{**}$ | -0.0102 | 0.0413$^{***}$ | 13,228 | 1,149,398 |
| | (0.377) | (0.0140) | (0.0148) | (0.0139) | | |

**Notes:** Superstars' games are excluded. A top player is defined as having an ELO rating in the top 25% among the competitors at the time of the tournament. All regressions include player and year fixed effects, round fixed effects, event site fixed effects, average ELO in a tournament (except Fischer's sample), player's side (white or black), and number of moves played. Clustered standard errors (clustered by tournament) are shown in parentheses.

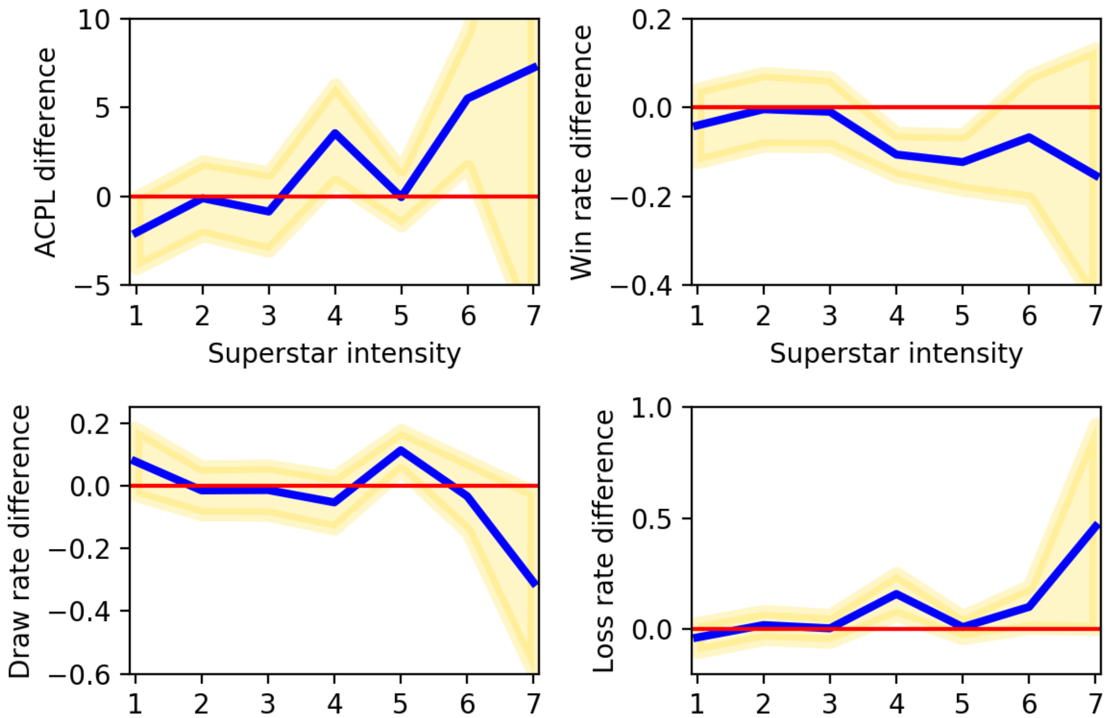
$^{+}$: These are the players with the top 2 highest ELO rating in a given tournament following Rausis' ELO rating. In a Swiss type open tournament, only the very top players have a chance to win the tournament.

$^{++}$: Since no ELO rating information was available in Fischer's era, we define the top players as the top chess players in the world from 1962-1970 other than Fischer. These players are Tigran Petrosian, Viktor Korchnoi, Boris Spassky, Vasily Smyslov, Mikhail Tal, Mikhail Botvinnik, Paul Keres, Efim Geller, David Bronstein, and Samuel Reshevsky.

$^{+++}$: The sample restricted to Round-robin tournaments with average ELO information available.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

**Figure 15:** Superstar presence coefficients for top players over different superstar intensity levels.




**Note:** The figure presents the coefficients in Table 11 with confidence intervals over different superstar intensity levels. Using magnitudes for dominance in terms of head-to-head competition presented in Table 2, we construct the superstar intensity scale as follows: 1=Carlsen, 2=Karpov, 3=Kasparov, 4=Kasparov & Karpov, 5=Fischer, 6=Hou Yifan, 7=Rausis.

# Appendix

**Table A.1:** Variables list.

| **Variable Name** | **Variable Meaning** |
|---|---|
| Superstar Present | =1 if a superstar is present in a tournament. |
| Against Superstar | =1 if a game is played against a superstar. |
| ELO | ELO rating of a player. |
| ACPL | Average Centipawn Loss of a player in a game. |
| win | =1 if a player wins his game. |
| draw | =1 if a games ends in a draw. |
| loss | =1 if a player loses his game. |
| white | =1 if a player's side is white. |
| moves | number of moves played in a game. |

**Table A.2:** An example pgn file.

| |
|---|
| [Event "GRENKE Chess Classic"] |
| [Site "Karlsruhe GER"] |
| [Date "2019.04.20"] |
| [EventDate "2019.04.20"] |
| [Round "1"] |
| [Result "0-1"] |
| [White "Vincent Keymer"] |
| [Black "Magnus Carlsen"] |
| [ECO "A56"] |
| [WhiteElo "2516"] |
| [BlackElo "2845"] |
| [PlyCount "162"] |

**1 d4 ♘f6 2 c4 c5 3 d5 g6 4 ♘c3 d6 5 e4 ♗g7 6 ♘f3 O-O 7 ♗e2 e5 8 O-O ♘e8 9 ♘e1 f5 10 e×f5 g×f5 11 f4 ♘d7 12 ♘d3 e4 13 ♘f2 ♗×c3 14 b×c3 ♘df6 15 ♗e3 ♘g7 16 ♕e1 ♗d7 17 ♘d1 ♗a4 18 h3 ♗×d1 19 ♕×d1 ♕e8 20 ♔f2 ♕g6 21 ♖g1 ♔h8 22 a4 ♖g8 23 ♕f1 ♘fh5 24 g3 ♖af8 25 ♕g2 ♕f6 26 ♖ac1 ♕d8 27 ♕h2 ♘f6 28 g4 ♘d7 29 g5 ♕a5 30 g6 h6 31 ♖b1 ♖b8 32 ♕g3 ♕d8 33 ♔e1 ♘e8 34 ♔d2 ♘f8 35 ♗f2 ♕e7 36 ♔e3 ♕f6 37 ♔d2 ♘×g6 38 h4 ♘e7 39 ♕h3 ♖×g1 40 ♖×g1 ♕f7 41 h5 ♘f6 42 ♗h4 b6 43 ♖b1 ♕f8 44 ♖g1 ♕f7 45 ♖b1 ♕g7 46 ♖g1 ♕f8 47 ♔c2 ♘fg8 48 ♔d2 ♕f7 49 ♔c2 ♖f8 50 ♔d2 ♕e8 51 ♖a1 ♖f7 52 a5 b×a5 53 ♖×a5 ♘c8 54 ♖a1 ♕f8 55 ♖b1 ♘b6 56 ♖g1 ♖g7 57 ♖×g7 ♔×g7 58 ♕g3+ ♔h8 59 ♕g6 a5 60 ♗f1 a4 61 ♔c2 a3 62 ♔b3 ♘a4 63 ♗h3 ♕g7 64 ♕×g7+ ♔×g7 65 ♗×f5 ♘f6 66 ♔×a3 ♘×c3 67 ♗f2 ♘e2 68 ♔a4 ♘×h5 69 ♔a5 ♘f6 70 ♔b6 ♔f7 71 ♔c7 ♔e7 72 ♗e3 ♘d4 73 ♗g6 h5 74 ♗f2 ♘f3 75 ♗f5 ♘d2 76 ♗h4 e3 77 ♗d3 ♘f3 78 ♗×f6+ ♔×f6 79 ♔×d6 h4 80 ♔c7 ♘d4 81 ♔c8 e2 0-1**

**Figure A.1:** An example tournament table.

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| | Player | Elo | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | TB | Perf. | +/- |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Carlsen,Magnus** | 2845 | * | ½ | ½ | 1 | ½ | 1 | 1 | 1 | 1 | 1 | 7.5 / 9 | | 2990 | +14 |
| 2 | **Caruana,Fabiano** | 2819 | ½ | * | 1 | ½ | ½ | ½ | ½ | ½ | 1 | 1 | 6.0 / 9 | | 2833 | +3 |
| 3 | **Naiditsch,Arkadij** | 2695 | ½ | 0 | * | ½ | 1 | ½ | 0 | ½ | 1 | 1 | 5.0 / 9 | 19.00 | 2766 | +9 |
| 4 | **Vachier Lagrave,Maxime** | 2773 | 0 | ½ | ½ | * | ½ | ½ | ½ | ½ | 1 | 1 | 5.0 / 9 | 18.25 | 2758 | -1 |
| 5 | **Anand,Viswanathan** | 2774 | ½ | ½ | 0 | ½ | * | ½ | ½ | 1 | 0 | 1 | 4.5 / 9 | 19.75 | 2719 | -6 |
| 6 | **Aronian,Levon** | 2763 | 0 | ½ | ½ | ½ | ½ | * | 1 | ½ | ½ | ½ | 4.5 / 9 | 18.75 | 2720 | -5 |
| 7 | **Svidler,Peter** | 2735 | 0 | ½ | 1 | ½ | ½ | 0 | * | ½ | 1 | ½ | 4.5 / 9 | 17.75 | 2723 | -1 |
| 8 | **Vallejo Pons,Francisco** | 2693 | 0 | ½ | ½ | ½ | 0 | ½ | ½ | * | ½ | 1 | 4.0 / 9 | | 2689 | -1 |
| 9 | **Meier,Georg** | 2628 | 0 | 0 | 0 | 0 | 1 | ½ | 0 | ½ | * | 0 | 2.0 / 9 | 8.75 | 2518 | -12 |
| 10 | **Keymer,Vincent** | 2516 | 0 | 0 | 0 | 0 | 0 | ½ | ½ | 0 | 1 | * | 2.0 / 9 | 6.50 | 2529 | +1 |

*Average Elo: 2724 < = > Cat: 19*

*gm = 3.24 m = 1.44*

(45 Games)

**Note:** The tournament table is obtained from Chessbase Mega Database 2020.

**Table A.3:** List of tournaments (classical)

| **Year** | *Tournament Name* |
|---|---|
| | *Panel A. Carlsen Present* |
| **2019** | GCT Croatia 2019, Grenke Chess Classic 2019, Gashimov Memorial 2019, Norway Chess 2019, Sinquefield 2019, Tata Steel 2019 |
| **2018** | Gashimov Memorial 2018, Sinquefield 2018, Biel 2018, Norway Chess 2018, Grenke Chess Classic 2018, Tata Steel 2018 |
| **2017** | London Classic 2017, Norway Chess 2017, Sinquefield 2017, Grenke Chess Classic 2017, Tata Steel 2017 |
| **2016** | Norway Chess 2016, Tata Steel 2016, Bilbao Masters 2016 |
| **2015** | London Classic 2015, Sinquefield 2015, Norway Chess 2015, Gashimov Memorial 2015, Grenke Chess Classic 2015, Tata Steel 2015 |
| **2014** | Norway Chess 2014, Zuerich Chess Challange 2014, Sinquefield 2014, Gashimov Memorial 2014 |
| **2013** | Moscow Tal Memorial 2013, Norway Chess 2013, Candidates Tournament 2013, Tata Steel 2013, Sinquefield 2013 |
| | *Panel B. Carlsen Not Present* |
| **2019** | U.S. Championship 2019, Dortmund 2019 |
| **2018** | Candidates Tournament 2018, U.S. Championship 2018, Dortmund 2018 |
| **2017** | U.S. Championship 2017, Dortmund 2017, Gashimov Memorial 2017 |
| **2016** | London Classic 2016, Sinquefield 2016, Gashimov Memorial 2016, Candidates Tournament 2016, Moscow Tal Memorial 2016, U.S. Championship 2016, Dortmund 2016 |
| **2015** | Dortmund 2015, Zuerich Chess Challenge 2015, Tbilisi FIDE GP 2015, Khanty-Mansiysk FIDE GP 2015, Capablanca Memorial 2015, U.S. Championship 2015 |
| **2014** | Beijing Sportaccord Basque 2014, London Classic 2014, Tashkent FIDE GP 2014, Dortmund 2014, Tata Steel 2014, U.S. Championship 2014, Candidates Tournament 2014, Baku FIDE GP, Capablanca Memorial 2014, Bergomo ACP Golden Classic 2014 |
| **2013** | Paris FIDE GP 2013, Dortmund 2013, Thessaloniki FIDE GP 2013, Zug FIDE GP 2013, Beijing FIDE GP 2013, Zuerich Chess Challenge 2013, Grenke Chess Classic 2013, Capablanca Memorial 2013, U.S. Championship 2013 |

**Table A.4:** List of tournaments (classical)

| **Year** | *Tournament Name* |
|---|---|
| | *Panel A. Kasparov Present* |
| **2001** | Astana 2001, Zuerich 2001, Linares 2001, Corus Wijk aan Zee 2001 |
| **2000** | Fujitsu Siemens Giants 2000, Sarajevo Bosnia 2000, Linares 2000, Corus Wijk aan Zee 2000 |
| **1999** | Sarajevo Bosnia 1999, Linares 1999, Hoogovens Wijk aan Zee 1999 |
| **1998** | Linares 1998 |
| **1997** | Tilburg 1997, Novgorod 1997, Linares 1997 |
| **1996** | Las Palmas 1996, Dos Hermanas 1996, Amsterdam Euwe Memorial 1996 |
| **1995** | Horgen 1995, Amsterdam Euwe Memorial 1995, Novgorod 1995 |
| | Riga Tal Memorial 1995 |
| | *Panel B. Kasparov Not Present* |
| **2001** | Sigeman & Co 2001, Biel 2001, Dortmund 2001, Pamplona 2001, Dos Hermanas 2001 |
| **2000** | Japfa Classic 2000, Dortmund 2000, Sigeman & Co 2000, Biel 2000 |
| **1999** | Pamplona 1999, Lost Boys Amsterdam 1999, Dortmund 1999, Sigeman & Co 1999 |
| | Dos Hermanas 1999, Biel 1999 |
| **1998** | Hoogovens Wijk aan Zee 1998, Tilburg 1998, Dortmund 1998, Madrid 1998, Pamplona 1998 |
| **1997** | Hoogovens Merrillville 1997, Sigeman & Co 1997, Ubeda 1997, Hoogovens Wijk aan Zee 1997 |
| | Dos Hermanas 1997, Lost Boys 1997, Dortmund 1997, Madrid 1997, Belgrade Investbank 1997 |
| **1996** | Koop Tjuchem 1996, Donner Memorial 1996, Hoogovens Wijk aan Zee 1996, |
| | Tilburg 1996, Dortmund 1996, Dos Hermanas 1996, Madrid 1996 |
| **1995** | Belgrade Investbank 1995, Horgen 1995, Donner Memorial 1995, Biel 1995, Madrid 1995, |
| | Dos Hermanas 1995, Groningen 1995, Dortmund 1995 |

**Table A.5:** List of tournaments (classical)

| **Year** | *Tournament Name* |
|---|---|
| | *Panel A. Kasparov & Karpov Both Present* |
| **1994** | Linares 1994 |
| **1993** | Linares 1993 |
| **1992** | |
| **1991** | Reggio Emilia 1991, Tilburg 1991, Amsterdam Euwe Memorial 1991, Linares 1991 |
| **1990** | |
| **1989** | World Cup Skelleftea 1989 |
| **1988** | USSR Championship 1988, World Cup Belfort 1988, Optiebeurs Amsterdam 1988 |
| **1987** | Brussels 1987 |
| | *Panel A. Kasparov & Karpov Neither Present* |
| **1994** | Donner Memorial 1994, Dortmund 1994, Hoogovens Wijk aan Zee 1994, Groningen 1994, Munich 1994 |
| **1993** | Antwerp 1993, Amsterdam VSB 1993, Madrid 1993, Las Palmas 1993, Munich 1993 |
| **1992** | Alekhine Memorial 1992, Amsterdam Euwe Memorial 1992, Hoogovens Wijk aan Zee 1992, Groningen 1992, Munich 1992 |
| **1991** | World Cup Reykjavik 1991, Hoogovens Wijk aan Zee 1991, Groningen 1991, Munich 1991 |
| **1990** | Tilburg 1990, Hoogovens Wijk aan Zee 1990, Prague 1990, Groningen 1990, Munich 1990 |
| **1989** | Hoogovens Wijk aan Zee 1989, Groningen 1989, Munich 1989, Amsterdam Euwe Memorial 1989 |
| **1988** | Amsterdam Euwe Memorial 1988, OHRA Amsterdam 1988, Linares 1988, Hastings 1988 |
| **1987** | Belgrade Investbanka 1987, Hoogovens Wijk aan Zee 1987, Interpolis 1987, OHRA Amsterdam 1987, Reykjavik 1987 |

**Table A.6:** List of tournaments (classical)

| **Year** | *Tournament Name* |
|---|---|
| | *Panel A. Karpov Present* |
| **1983** | Interpolis 1983, International DSB Mephisto GM 1983, USSR Final 1983, Bath 1983, Linares 1983 |
| **1982** | Interpolis 1982, Turin 1982, Hamburg 1982, London Phillips 1982, Mar del Plata Clarin Masters 1982 |
| **1981** | IBM Herinnerungs Toernooi 1981, Moscow 1981, Linares 1981 |
| **1980** | Buenos Aires 1980, Interpolis 1980, IBM Kroongroep 1980, Bugojno 1980, Bad Kissingen 1980 |
| **1979** | Interpolis 1979, Waddinxveen KATS 1979, Montreal International 1979, GER International 1979 |
| **1978** | Bugojno 1978 |
| **1977** | Interpolis 1977, October Revolution 1977, Las Palmas 1977, GER International 1977 |
| **1976** | USSR Final 1976, Montilla 1976, Manila Marlboro 1976, Amsterdam 1976, Skopje Solidarnost 1976 |
| | *Panel B. Karpov Not Present* |
| **1983** | Jakarta International 1983, Hoogovens Wijk aan Zee 1983 |
| **1982** | Interzonal 1982, Hoogovens Wijk aan Zee 1982 |
| **1981** | Las Palmas 1981, IBM Herinnerungs Toernooi 1981, Interpolis 1981, Hoogovens Wijk aan Zee 1981 |
| **1980** | Buenos Aires 1980, London Phillips 1980, Hoogovens Wijk aan Zee 1980, Las Palmas 1980, Reykjavik International 1980 |
| **1979** | Buenos Aires Clarin 1979, Interzonal 1979, Vidmar Memorial 1979, IBM 1979 Hoogovens Wijk aan Zee 1979, Buenos Aires Konex 1979 |
| **1978** | Interpolis 1978, Reykjavik International 1978, Hoogovens Wijk aan Zee 1978, Las Palmas 1978 IBM 1978, Clarin 1978 |
| **1977** | Geneve 1977, Vidmar Memorial 1977, Hoogovens Wijk aan Zee 1977, IBM 1977 |
| **1976** | Interzonal 1976, Las Palmas 1976, Reykjavik International 1976, Hoogovens Wijk aan Zee 1976, IBM 1976 |

**Table A.7:** List of tournaments (classical)

| **Year** | *Tournament Name* |
|---|---|
| | *Panel A. Fischer Present* |
| **1970** | Interzonal 1970, Buenos Aires 1970, Rovinj Zagreb 1970 |
| **1969** | |
| **1968** | Vinkovci 1968, Nathanya 1968, |
| **1967** | Skopje 1967, Monaco Grand Prix 1967, Interzonal 1967 |
| **1966** | Piatigorsky Cup 1966, U.S. Championship 1966 |
| **1965** | U.S. Championship 1965, Capablanca Memorial 1965 |
| **1964** | |
| **1963** | U.S. Championship 1963 |
| **1962** | U.S. Championship 1962, Candidates Tournament 1962, Interzonal 1962 |
| | *Panel B. Fischer Not Present* |
| **1970** | Vinkovci 1970, IBM Amsterdam 1970, Budapest 1970, Sarajevo 1970, Caracas 1970, Hoogovens Wijk an Zee 1970, Costa del Sol 1970, Skopje 1970, Rubinstein Memorial 1970, Christmas Congress 1970 |
| **1969** | Monaco Grand Prix 1969, Hoogovens Wijk an Zee 1969, Venice 1969 U.S. Championship 1969, Palma de Mallorca 1969, IBM Amsterdam 1969, Sarajevo 1969, Christmas Congress 1969, Rubinstein Memorial 1969, Capablanca Memorial 1969 |
| **1968** | Rubinstein Memorial 1968, Christmas Congress 1968, Palma de Mallorca 1968, U.S. Championship 1968, Bamberg 1968, IBM Amsterdam 1968, Sarajevo 1968 Hoogovens Wijk an Zee 1968, Monaco Grand Prix 1968, Skopje 1968 |
| **1967** | Winnipeg 1967, October Revolution Leningrad 1967, October Revolution Moscow 1967, Capablanca Memorial 1967, Palma de Mallorca 1967, Sarajevo 1967, Hoogovens Beverwijk 1967, Christmas Congress 1967, Rubinstein Memorial 1967, Venice 1967, IBM Amsterdam 1967 |
| **1966** | IBM Amsterdam 1966, Sarajevo 1966, Palma de Mallorca 1966 Hoogovens Beverwijk 1966, Venice 1966, Rubinstein Memorial 1966, Christmas Congress 1966 |
| **1965** | ZSK International 1965, Zagreb 1965, Mer del Plata 1965, IBM Amsterdam 1965, Sarajevo 1965, Hoogovens Beverwijk 1965, Christmas Congress 1965, Rubinstein Memorial 1965 |
| **1964** | Buenos Aires 1964, Capablanca Memorial 1964, Rubinstein Memorial 1964, Interzonal 1964, IBM Amsterdam 1964, Sarajevo 1964, Hoogovens Beverwijk 1964, Christmas Congress 1964, ZSK International 1964 |
| **1963** | Piatigorsky Cup 1963, Alekhine Memorial 1963, IBM Amsterdam 1963, Sarajevo 1963, Hoogovens Beverwijk 1963, Rubinstein Memorial 1963, Christmas Congress 1963, Capablanca Memorial 1963 |
| **1962** | Mer del Plata 1962, IBM Amsterdam 1962, Sarajevo 1962, Hoogovens Beverwijk 1962, Rubinstein Memorial 1962, Christmas Congress 1962, Capablanca Memorial 1962 |

**Table A.8:** List of tournaments (classical)

| Year | *Tournament Name* |
|---|---|
| | *Panel A. Hou Yifan Present* |
| **2015** | Monte Carlo FIDE GP 2015 |
| **2014** | Lopota FIDE GP 2014, Khanty-Mansiysk FIDE GP 2014, Sharjah FIDE GP 2014 |
| | *Panel B. Hou Yifan Not Present* |
| **2019** | Skolkovo FIDE GP 2019, Saint Louis Cairns Cup 2019 |
| **2016** | Khanty-Mansiysk FIDE GP 2016, Chengdu FIDE GP 2016, Batumi FIDE GP 2016, Tehran FIDE GP 2016 |

**Table A.9:** List of tournaments (classical)

| Year | *Tournament Name* |
|---|---|
| | *Panel A. Rausis Present* |
| **2019** | Lugano op 2019 |
| **2018** | Sautron op 2018 |
| **2017** | |
| **2016** | Salon de Provence op 2016 |
| **2015** | |
| **2014** | Chemnitz op 2014, Biella op 2014 |
| **2013** | Charleroi op 2013, Lueneburg op 2013 |
| **2012** | Tres Cantos op 2012 |
| | *Panel B. Rausis Not Present* |
| **2019** | Locarno op 2019, Ascona op 2019, Porto San Giorgio op 2019 |
| **2018** | Erfurt op 2018, Pfarrkirchen Rottal op 2018, Locarno op 2018, Paderborn op 2018, Forchheim op 2018 |
| **2017** | Pfarrkirchen Rottal op 2017, Porto San Giorgio op 2017 Lugano op 2017, Sautron op 2017 |
| **2016** | Wasselonne op 2016, Heraklion op 2016 |
| **2015** | Salon de Provence op 2015, Biella op 2015, Porto San Giorgio op 2015, Erfurt op 2015, Lugano op 2015, Ascona op 2015, Lugano op 2015, Forchheim op 2015 |
| **2014** | Salon de Provence op 2014, Paderborn op 2014, Erfurt op 2014 Arco op 2014, Ascona op 2014, Forchheim op 2014 |
| **2013** | Biella op 2013, Forchheim op 2013 |

**Table A.10:** Performance against Kasparov or Karpov.

| | *Panel A. Classical* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | *ACPL* | *win* | *draw* | *loss* |
| Against Kasparov | 4.043*** | -0.204*** | -0.0392 | 0.243*** |
| | (0.703) | (0.0198) | (0.0318) | (0.0258) |
| Against Karpov | 1.157 | -0.157*** | 0.0432 | 0.114** |
| | (1.331) | (0.0264) | (0.0386) | (0.0441) |
| Against Kasparov or Karpov | 3.656*** | -0.182*** | -0.0424 | 0.224*** |
| | (0.722) | (0.0192) | (0.0292) | (0.0285) |
| *Number of moves* | 232,709 | 232,709 | 232,709 | 232,709 |
| *Number of games* | 2,892 | 2,892 | 2,892 | 2,892 |

**Notes:** All regressions include player and year fixed effects, round fixed effects, event site fixed effects, average ELO in a tournament, player's side (white or black), and number of moves played. Clustered standard errors (clustered by tournament) are shown in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$