Dynamic tournaments and performance: Evidence from long jump competitions

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Introduction

As part of International Association of Athletics Federation (IAAF) competitions (the IAAF organization name was changed to World Athletics in 2019), long jump competitions are structured as sequential rank-order tournaments. In these long jump tournaments, athletes compete sequentially across multiple rounds of jumps and the athlete with the longest recorded jump across all jumps within that tournament is the winner. Using IAAF data on long jump competitions from 2005 to 2017, this paper investigates whether an athlete's live leaderboard rank impacts their performance on each jump of the tournament.

Our results indicate that an athlete's performance increases as the athlete's live leaderboard rank increases (note that a rank of 1 indicates that the athlete is the current leader of the tournament and athletes with higher ranks are closer to the bottom of the standings); however, we find a U-shaped relationship between rank and performance when looking at a different measure of performance. We also investigate whether the rank differentially impacts athletes across rounds of the tournament and we find mixed evidence regarding whether the impact varies across rounds. In addition, we investigate whether our results are sensitive to the fixed effects specification and we find that the pattern of the relationship between rank and performance is not affected as alternative fixed effects specifications are considered.

Competing in rank-order tournament settings can influence an individual's effort and performance, and these impacts have been investigated by many researchers, dating back to Lazear and Rosen (1981). More recently, research has looked at whether psychological pressure influences a participant's effort and performance within a rank-order tournament setting. (Psychological pressure is presumably higher when the participant is closer to the top of the rankings.) A competitor underperforming because of pressure is difficult to observe because pressure is not easily measured. Researchers using sports data have measured pressure using the order of the competition, monetary rewards, superstar presence, and interim rank.

Researchers who have looked at the impact of order on performance have found mixed results. Apesteguia and Palacios-Huerta (2010) and Vandebroek, McCann, and Vroom (2018) looked at penalty kick shootouts in soccer and found that the team kicking first had an advantage while Brady and Insler (2017) find that golfers playing second had an advantage. Hill (2014) and Emerson and Hill (2014) look at order of competition in track races and find limited evidence of an advantage to athletes who compete in the last heats of a competition.

Using a monetary measure of pressure, researchers have found that golfers underperform as the monetary incentives of the performance increase (Hickman and Metz, 2015). The presence of a superstar performer can also psychologically impact other competitors. Researchers have found evidence that this can be beneficial or harmful. Brown (2011) finds that the presence of Tiger Woods, a superstar performer, in a tournament lowers other competitors' performances, while Hill (2014) finds that the presence of Usain Bolt, a superstar, increases the performance of other athletes in the 100-meter competitions.

More closely related to this paper, researchers have found evidence that, in a tournament setting, an athlete's interim rank can affect that athlete's performance. Using data from weightlifting competitions, Genakos and Pagliero (2012) find that athletes tend to underperform when ranked closer to first place. Similarly, using data from diving competitions, Genakos, Pagliero, and Garbi (2015) find that divers ranked closer to the top tend to underperform. Hickman, Kerr, and Metz (2018) find similar results using data from golf tournaments; golfers tend to underperform when they are playing in the lead.

Similar to the golf setting (Hickman, Kerr, and Metz (2018)), one advantage to our setting is that athletes in long jump competitions attempt the exact same task in each round of the tournament: jump as far possible. Divers select their dives prior to the start of the competition and weightlifters must decide on the weight they will attempt prior to each lift. This means that divers and weightlifters are attempting different tasks as the tournament progresses.

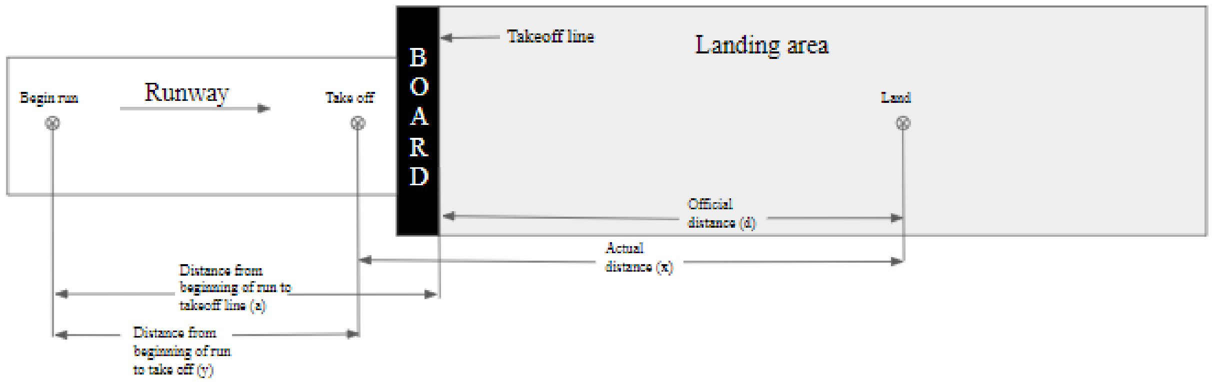
A significant difference between our setting and the golf setting is that tournament rankings in long jump competitions are determined using only the longest jump of each athlete. While a long jump athlete can improve their distance on the leaderboard when making another jump attempt, their leaderboard distance can never decline. While an improvement in distance might not improve the athlete's ranking, nothing the athlete does on a jump attempt can reduce their ranking. This feature of long jumps drives our decisions regarding how to measure performance.

An advantage of our setting over golf is the availability of interim rank information to all long jump athletes competing in the tournament. Hickman, Kerr, and Metz (2018) discuss the possibility that golfers who are ranked far from first place could potentially suffer from a lack of information regarding their live ranking. Since long jump tournaments have a common competition space and only twelve athletes in the finals, athletes have complete information about current rankings within the tournament. This allows us to remove information asymmetry as a potential determinant of our results.

Long jump competitions

In long jump tournaments, athletes compete over a series of rounds. In each round of the tournament, each athlete makes a single jump attempt. A jump attempt consists of an athlete sprinting down a runway and jumping as far as possible into a landing area filled with sand. At the end of the runway is a take-off board which the athlete targets to maximize their distance. The official distance of the jump (d) is recorded by measuring the distance from the edge of the takeoff line nearest to the landing area to the location in the sand where the athlete first made a break in the sand with their body, or anything attached to their body (see IAAF (2017) for more information about competition rules). The distance is measured to the nearest centimeter. If the athlete touches the ground beyond the takeoff board during the attempt (y>a), a foul is committed. When a foul is committed, the distance is not measured and the athlete is considered to have failed the attempt. See Figure 1 for an illustration (Figure 1 is the authors' drawing of a similar image seen in Ladany, Humes, and Sphicas (1975)).

Figure 1: Long jump diagram



The finishing position of the athletes within the tournament is determined by comparing the longest distance recorded for each athlete across all rounds of the tournament. If two or more athletes have the same longest distance, the athlete whose second longest recorded jump is farther is ranked better. If the athletes have the same second longest jump, relative positions are determined by looking at whose third longest jump is longer, and so on. In IAAF tournaments with more than eight competitors, all athletes in the finals are guaranteed at least three attempts. At the end of these initial three attempts, the eight athletes with the longest recorded distances are awarded three additional jumps. Note that in IAAF competitions, there is also a qualifying round where athletes compete over a similarly structured tournament, but the only goal is to qualify for the finals. All analysis in this paper examines only the finals.

Since there is only one long jump runway and landing area in each tournament, athletes take their jump attempts in sequential order. The tournament begins with each athlete taking their first jump attempt in sequence. The tournament then moves on to the second round where athletes take their second jump attempts in sequence. This process continues throughout the tournament and the within round sequence is determined by a particular set of rules. According to IAAF rules, the order for the first round of jump attempts is randomly determined by lots. This order then remains unchanged over the first three rounds. For the eight athletes who are awarded three additional jump attempts, the order for the final three rounds is a reverse ranking order of the athletes after the first three rounds. In other words, the athlete with the longest recorded distance after three rounds jumps last over the last three rounds of the tournament and the athlete with the eighth longest recorded distance after three rounds jumps first over the last three rounds.
This structure is the same for both male and female long jump tournaments.

Results from the women's long jump competition at the 2017 IAAF World Championships are summarized is Table 1. The table shows each athlete's results over the six rounds of the tournament along with their longest recorded jump at the completion of the tournament. Athletes are ordered by finishing position and this does not reflect the order in which the jumps were taken. As described above, the finishing position is determined based on the longest recorded jump after all attempts are taken. As seen in Table 1, Brittney Reese won the tournament with a jump of 7.02 meters which she recorded on her third attempt. When athletes were judged to have failed the attempt (foul committed), the distance of the jump was not measured and the athlete was awarded an X for that attempt.

Table 1: IAAF World Championships, 2017

Athlete	Attempt 1	2	3	4	5	6	Longest jump	Finishing position
Brittney Reese	6.75	X	7.02	X	X	X	7.02	1
Darya Klishina	6.78	6.88	X	6.91	7	6.83	7	2
Tianna Bartoletta	6.56	6.6	X	6.64	6.88	6.97	6.97	3
Ivana Španovic	X	6.96	6.77	X	X	6.91	6.96	4
Lorraine Ugen	X	X	6.72	X	X	6.4	6.72	5
Brooke Stratton	6.27	6.54	6.67	6.55	6.67	6.64	6.67	6
Chantel Malone	6.52	6.44	6.57	X	X	6.52	6.57	7
Blessing Okagbare-Ighoteguonor	6.4	6.55	6.47	6.49	X	6.31	6.55	8
Lauma Griva	6.54	X	6.42				6.54	9
Claudia Salman-Rath	6.39	6.29	6.54				6.54	10
Eliane Martins	6.52	X	X				6.52	11
Alina Rotaru	6.29	6.2	6.46				6.46	12

The table is ordered based on finishing position. It does not show the order in which the jumps were taken. X indicates that the athlete fouled on the attempt.

Data

Data collected include information on 113 athletes comprising 957 observations from the World Championships in Athletics and Olympics that occurred from 2005 to 2017. Table 2 provides averages for the recorded distance and probability of fouling across rounds by gender. As seen in the table, male athletes foul 33.8 percent of the time and between 27 and 39 percent of the time across rounds. When male athletes record an official distance, they jump from 7.94 to 8.08 meters. Female athletes foul 34.1 percent of the time and between 28 and 45 percent of the time across rounds. When female athletes record an official distance, they jump from 6.56 to 6.75 meters.

Table 2: Averages by round and gender

	Overall	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6
Male							
Distance (meters)	8.018	7.943	8.017	7.944	8.060	8.078	8.037
Foul	0.338	0.274	0.284	0.316	0.359	0.375	0.391
Female							
Distance (meters)	6.625	6.559	6.593	6.578	6.636	6.750	6.636
Foul	0.341	0.333	0.333	0.281	0.375	0.453	0.297

Source: Authors' calculations based on data from IAAF World Championships and Olympics from 2005-2017.

Given our interest in the impact of interim rank on performance, it is important to consider how performance is measured. As discussed previously, athletes in long jump competitions attempt the same task throughout each round of the tournament: jump as far as possible. Accordingly, the actual distance of the jump (x in Figure 1) is one possible measure. However, this measure is not observed because the distance from the athlete's takeoff to the takeoff line is not measured. The recorded distance of the jump (d in Figure 1) is also problematic as a source of performance in our setting. One issue with this measure is the prevalence of fouls. Within our sample, athletes foul on roughly 34 percent of their attempts which means we do not have a recorded distance for these attempts. An additional issue with using this measure is that the tournament is a rank-order tournament where relative performance is what determines position and only an athlete's longest recorded jump is used in making this comparison.

Given that an athlete's longest jump is what determines finishing position, we explore a measure of performance that captures whether an athlete improves upon their longest jump so far in the tournament. We call this measure $improve_{ita}$, and it is equal to one if athlete *i* in tournament *t* has a longer recorded distance on attempt *a* than their longest recorded distance before attempt *a*, and zero otherwise. This measure is not calculated for athletes who did not have a longest recorded distance prior to attempt *a*, which rules out all jumps during round 1 and any athletes who have only fouled.

One drawback to the use of this measure is that the measure does not capture what happened to the athlete's current standings in the tournament. An athlete could fail to improve their longest jump but maintain their position on the leaderboard as long as no other athletes surpassed them. Ultimately, what an athlete is concerned with is their relative position in the tournament. As a result, we construct a measure called $success_{itr}$. For athletes who were not in last position in round *r*, this variable is equal to one if athlete *i* in tournament *t* has the same position or better after round *r*+1 relative to their position after round *r*, and zero otherwise. For athletes who were in last position in round *r*, this variable is equal to one if athlete *i* in tournament *t* has a better position after round *r*+1 relative to being in last position after round *r*, and zero otherwise. This measure requires the completion of the first round for an athlete's end of round position so does not include jumps during round 1.

Table 3 presents the probability of improve and success by round and gender. As seen in the table, male athletes improve 27.59 percent of the time and female athletes improve 21.16 percent of the time. For male athletes, this varies between 14 and 40 percent across rounds, and for female athletes, this varies between 12 and 31 percent across rounds. Male athletes are successful at maintaining or improving their positions 59.16 percent of the time and female athletes are successful 61.2 percent of the time. Across rounds, this varies between 38 and 76 percent for male athletes and between 39 and 76 percent for female athletes. While the probability of improving seems to be lower in later rounds, the probability of success is highest in later rounds.

Table 3: Probability of Improve and Success by round and gender

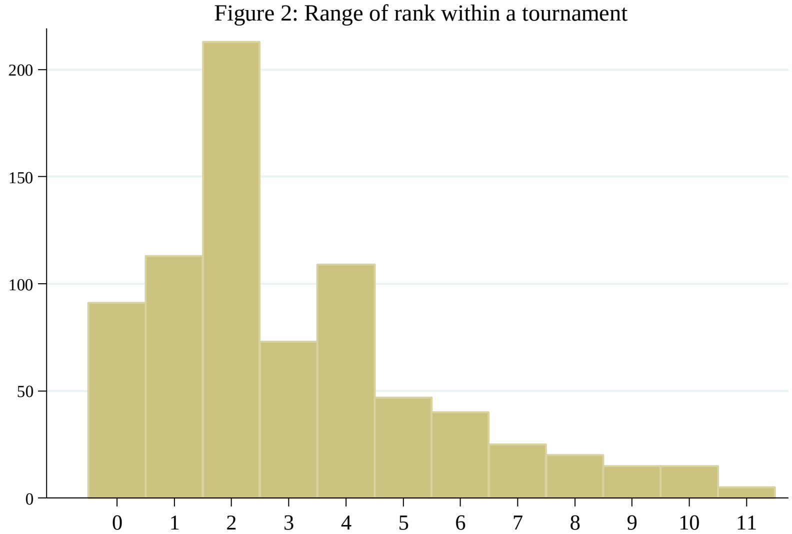
	Male					
	Overall	Round 2	Round 3	Round 4	Round 5	Round 6
Improve	27.59	40.58	33.33	14.06	26.56	20.31
Success	59.16	38.95	57.89	68.75	64.06	76.56
	Female					
	Overall	Round 2	Round 3	Round 4	Round 5	Round 6
Improve	21.16	25.00	31.46	14.06	18.75	12.50
Success	61.20	39.58	63.54	68.75	67.19	76.56

Source: Authors' calculations based on data from IAAF World Championships and Olympics from 2005-2017.

With measures of performance determined, we next consider the construction of our interim rank variable. As discussed previously, the sequential nature of long jump tournaments allows for athletes to observe a live updated leaderboard with information from all jumps in the tournament including the jump by the immediately preceding athlete. With this in mind, we have constructed a live leaderboard $rank_{itj}$ where rank is athlete *i* in tournament *t*'s live leaderboard rank at jump *j*, which includes all information in the tournament up to and including jump *j*-1. With the live leaderboard, athletes beginning with the second jump of the tournament (j=2) have a sense of their live leaderboard rank. However, our measures of performance utilize only jumps beginning in the second round so the analysis only includes information from rounds 2-6.

Variability of *rank* for a given athlete within a tournament is substantial. Figure 2 presents the range of *rank* for a given athlete within a tournament. Range is defined as the difference between an athlete's maximum *rank* within a tournament and their minimum *rank*. On average, the difference between the maximum and minimum live leaderboard *rank* for a given individual within a competition is 3.06 positions, with the 25th percentile experiencing a change of one position and the 75th percentile experiencing a change of four positions.

Figure 2: Range of rank within a tournament



Source: Authors' calculations based on data from IAAF World Championships and Olympics from 2005-2017.

Before estimating the relationship between rank and performance, we consider some initial examinations. Figure 3 shows the probability of improve and success by rank. In general, the probability of improving increases as an athlete's live leaderboard rank increases (further from the tournament leader) and the probability of success decreases as an athlete's live leaderboard rank increases.

Empirical strategy

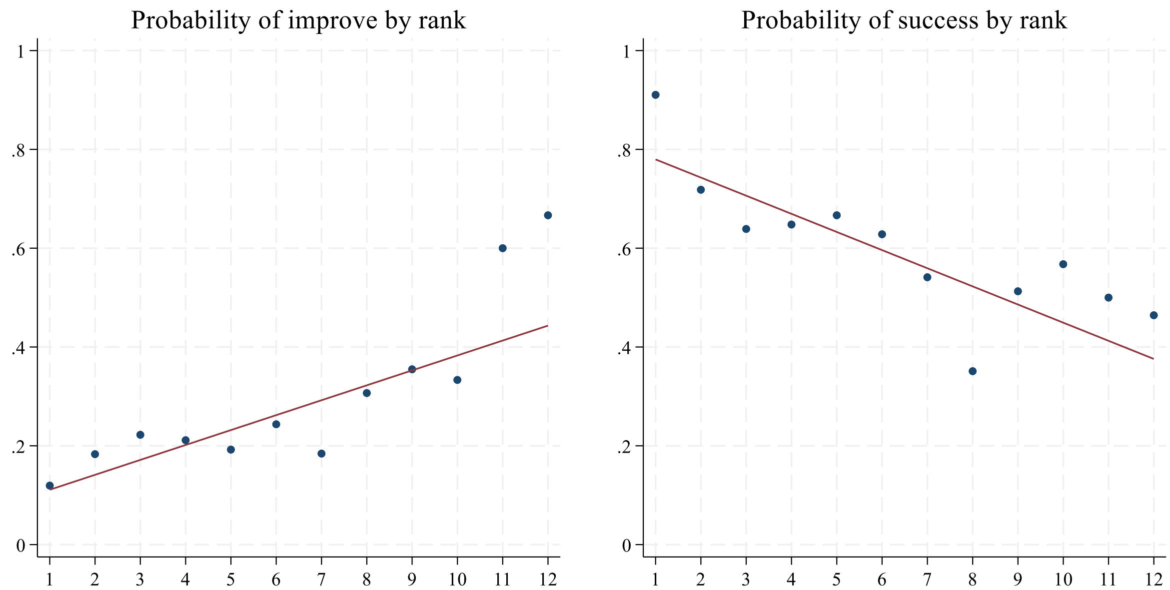
We begin by examining the impact of *rank* on performance by estimating a model of the following form:

$$performance = \alpha + \beta\, rank_{itj} + \lambda_i + \lambda_t + \lambda_a + \varepsilon_{ita} \qquad (1)$$

where *performance* is measured separately as $improve_{ita}$ and $success_{itr}$ as defined above. λ_i represents athlete-specific fixed effects, λ_t represents tournament-specific fixed effects, λ_a

represents attempt-specific fixed effects, and ε_{ita} is an error term that is clustered by athlete. Note that we also estimate models with standard errors clustered by attempt and results are unchanged so are not included. The athlete fixed effect is included to control for athlete-specific unobserved heterogeneity, the tournament fixed effect is included to control for variables that are fixed within a given tournament, and the attempt fixed effect is included to control for attempt-specific heterogeneity. We also explore alternative fixed effect specifications later in the paper.

Figure 3: Probabilities by rank



Source: Author's calculations on data from IAAF World Championships and Olympics from 2005-2017.

We begin our estimations by including *rank* as a continuous variable. We then explore whether the relationship is non-linear by including *rank* and *rank*^{2}. Finally, we also estimate models where *rank* is included as a series of dummy variables for specific live leaderboard *rank* values (rank 1 for the current leader through rank 12 for current last place). Due to the nature of the tournament, it is possible that any interim rank impact differs based on the round of the tournament. To consider this, we also estimate a model in which we interact our *rank* variable with the attempt fixed effect.

Results

Table 4 presents linear probability estimates of equation (1). Note that Probit models were also estimated for all specifications and results were similar so are not included. Columns (1)-(3) provide estimates for the *improve* measure of performance and columns (4)-(6) provide estimates for the *success* measure of performance. In column (1), we see that an athlete's probability of improving increases as the athlete's live leaderboard rank increases (gets further below the leader). Results in column (2) are evidence that the relationship between rank and improve is quadratic, a statement we investigate below. Column (3) shows estimates of the impact of rank relative to being ranked first. Estimates indicate that athletes are significantly more likely to improve when ranked at positions higher than first.

Table 4: Impact of rank on performance

	(1)	(2)	(3)	(4)	(5)	(6)
	Improve	Improve	Improve	Success	Success	Success
rank	0.066***	-0.018		0.009	-0.088***	
	(0.010)	(0.031)		(0.008)	(0.027)	
$rank^2$		0.008***			0.008***	
		(0.003)			(0.002)	
rank 2			0.088			-0.171**
			(0.103)			(0.082)
rank 3			0.126			-0.326***
			(0.097)			(0.080)
rank 4			0.158			-0.290***
			(0.116)			(0.095)
rank 5			0.150			-0.195**
			(0.092)			(0.087)
rank 6			0.212**			-0.180**
			(0.098)			(0.088)
rank 7			0.266***			-0.202**
			(0.100)			(0.080)
rank 8			0.427***			-0.333***
			(0.101)			(0.081)
rank 9			0.550***			-0.041
			(0.136)			(0.121)
rank 10			0.551***			0.236**
			(0.152)			(0.103)
rank 11			0.765***			-0.053
			(0.134)			(0.121)
rank 12			1.126***			-0.001
			(0.184)			(0.159)
Athlete FE	Yes	Yes	Yes	Yes	Yes	Yes
Tournament FE	Yes	Yes	Yes	Yes	Yes	Yes
Attempt FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	693	693	693	766	766	766

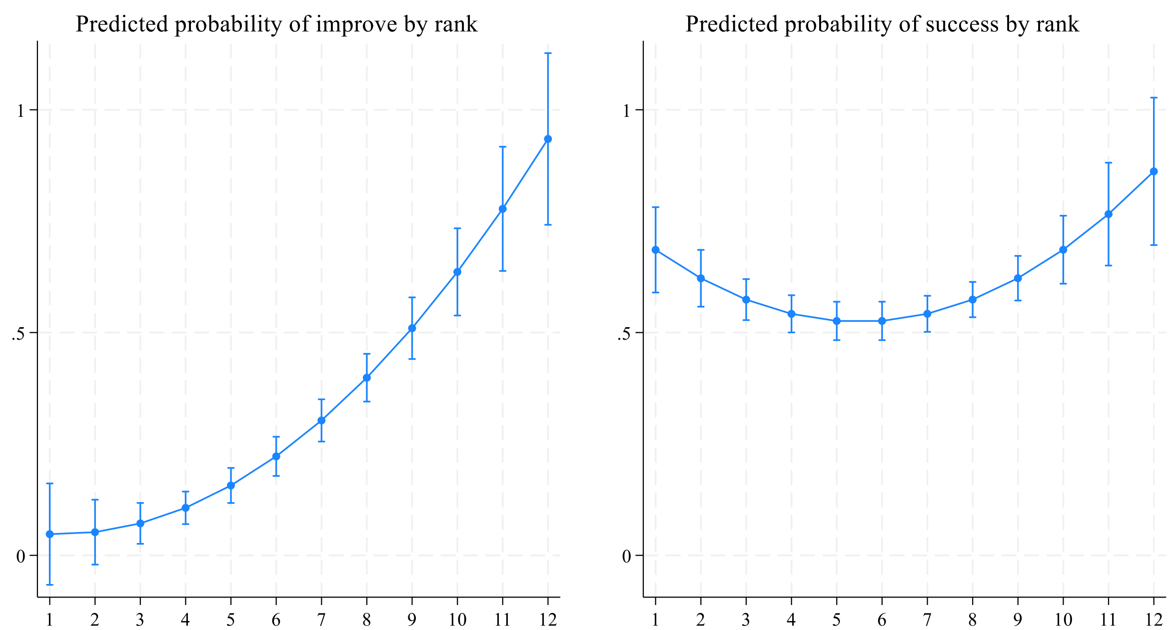
The table displays linear probability estimates with standard errors clustered by the athlete. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

In column (4), we see that there is not a statistically significant linear relationship between an athlete's probability of success and the athlete's live leaderboard rank. Results in column (5) are evidence that the relationship between rank and success is U-shaped which we investigate below. Finally, column (6) shows estimates of the impact of rank relative to being ranked first.

Estimates indicate that athletes at relatively better rankings (closer to first) are significantly less likely to be successful. In our definition of success, an athlete maintaining last place doesn't count as a success even though maintaining any other position does count as a success. As a robustness check, the model was estimated with athletes in last place dropped and the results were essentially unchanged, so are not reported here.

To investigate whether the relationship between rank and performance is non-linear, we consider the predicted probabilities by rank from columns (2) and (5) in Table 4. Figure 4 shows the predicted probabilities by rank across both performance measures. As seen in the figure, the relationship between rank and performance is U-shaped for each of our performance measures. Based on estimates from column (2) in Table 4, the relationship between rank and improve is U-shaped and reaches a minimum at a rank of 1.21. Based on estimates from column (5) in Table 4, the relationship between rank and success is U-shaped and reaches a minimum at a rank of 6.12.

Figure 4: Predicted probabilities by rank



Results from Table 4 provide evidence that an athlete with a higher live leaderboard rank (further from first place) performs at a higher level. We next investigate whether the impact of rank varies across attempt by expanding model (1) to include interactions between *rank* and *attempt*.

$$performance = \alpha + \sum\{\beta \; d.rank\} + \sum\{\delta \; (d.attempt * d.rank)\} + \lambda_i + \lambda_t + \lambda_a + \varepsilon_{ita} \quad (2)$$

Where *d. rank* represents a set of dummy variables for rank (1-12) and *d.attempt* represents a set of dummy variables for attempt (2-6).

After estimating model (2), we obtain the marginal effects of rank by attempt. Table 5 shows the marginal effects obtained from the model where performance is measured with *improve*. In attempts 2 and 3, we see evidence that athletes ranked below the middle of the standings are more likely to improve relative to being ranked first, and the results are somewhat similar for attempt 4. In attempt 5, only eighth ranked athletes have a significantly different (positive) probability of improving relative to being ranked first. However, in attempt 6, all other ranks have a significantly higher probability of improving relative to being ranked first.

Table 5: Impact of rank on improve by attempt

	attempt 2	attempt 3	attempt 4	attempt 5	attempt 6
rank 2	0.076	0.131	0.054	-0.076	0.305*
	(0.198)	(0.196)	(0.080)	(0.182)	(0.171)
rank 3	-0.115	0.065	0.130	0.211	0.396**
	(0.200)	(0.205)	(0.101)	(0.211)	(0.167)
rank 4	-0.051	0.242	0.120	0.203	0.329**
	(0.224)	(0.196)	(0.114)	(0.205)	(0.133)
rank 5	-0.041	0.155	0.185*	0.244	0.228*
	(0.208)	(0.196)	(0.104)	(0.223)	(0.123)
rank 6	0.010	0.237	0.191	0.237	0.320**
	(0.170)	(0.219)	(0.164)	(0.200)	(0.148)
rank 7	0.488*	0.144	0.334**	0.135	0.196**
	(0.247)	(0.185)	(0.140)	(0.178)	(0.093)
rank 8	0.456**	0.423**	0.367***	0.401*	0.470***
	(0.224)	(0.185)	(0.125)	(0.202)	(0.138)
rank 9	0.537**	0.516**			
	(0.224)	(0.243)			
rank 10	0.400	0.642***			
	(0.272)	(0.223)			
rank 11	0.520*	0.885***			
	(0.274)	(0.200)			
rank 12	1.004***	1.099***			
	(0.313)	(0.296)			
Athlete FE	Yes				
Tournament FE	Yes				
Attempt FE	Yes				
Observations	693				

The table displays marginal effects of rank by attempt, using model (2). ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6 presents the marginal effects of rank by attempt where performance is measured with *success*. In attempt 2, athletes ranked closer to the top of the rankings (3, 4, 5, 6) are significantly less likely to be successful relative to being ranked first. In attempt 3, we see evidence that athletes ranked second are less likely to be successful and athletes ranked 10 are more likely to be successful relative to being ranked first. In attempt 4, athletes ranked third, seventh, and eighth are less likely to be successful relative to being ranked first. Similarly, in attempt 5, athletes ranked third, fourth, sixth, and eighth are less likely to be successful relative to being ranked first. Finally, in attempt 6, we see that athletes ranked sixth are more likely to be successful and athletes ranked eighth are less likely to be successful relative to being ranked first.

Table 6: Impact of rank on success by attempt

	attempt 2	attempt 3	attempt 4	attempt 5	attempt 6
rank 2	-0.407	-0.312*	0.032	-0.155	0.059
	(0.248)	(0.183)	(0.083)	(0.128)	(0.124)
rank 3	-0.563**	-0.224	-0.457***	-0.371**	-0.109
	(0.229)	(0.173)	(0.121)	(0.147)	(0.160)
rank 4	-0.646***	0.044	-0.173	-0.510***	-0.139
	(0.192)	(0.183)	(0.147)	(0.160)	(0.144)
rank 5	-0.440*	-0.255	-0.148	-0.076	0.005
	(0.236)	(0.191)	(0.110)	(0.129)	(0.156)
rank 6	-0.427*	-0.197	-0.261	-0.302**	0.237*
	(0.253)	(0.268)	(0.162)	(0.121)	(0.120)
rank 7	-0.327	-0.336	-0.427***	-0.214	0.085
	(0.206)	(0.216)	(0.148)	(0.160)	(0.155)
rank 8	-0.291	0.087	-0.453***	-0.619***	-0.500***
	(0.214)	(0.188)	(0.121)	(0.102)	(0.158)
rank 9	-0.025	-0.200			
	(0.206)	(0.216)			
rank 10	0.051	0.436**			
	(0.190)	(0.193)			
rank 11	-0.150	-0.047			
	(0.204)	(0.189)			
rank 12	-0.138	0.031			
	(0.257)	(0.230)			
Athlete FE	Yes				
Tournament FE	Yes				
Attempt FE	Yes				
Observations	766				

The table displays marginal effects of rank by attempt, using model (2). ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Robustness checks

Models above included separate fixed effects for athlete, tournament, and attempt. Previous research (Genakos and Pagliero, 2012; Genakos, Pagliero, and Garbi, 2015; and Hickman, Kerr, and Metz, 2018) has investigated using alternative fixed effects when estimating the impact of interim rank on performance and found that fixed effect specification can alter results. We also explore an alternative fixed effect specification to see if our results are robust to the choice of fixed effects. The results above suggest that the relationship between *rank* and *performance* is quadratic, so we focus our examination of the impact of fixed effect specification on these models.

All estimates so far have included separate athlete, tournament, and attempt fixed effects. Our alternative specification includes tournament and attempt fixed effects but no athlete fixed effects. With no athlete fixed effects, we include some athlete-specific control variables in order to control for athlete-specific influences. Given our dataset, we are able to add an athlete's season best jump (*sb*), a dummy variable equal to one if the athlete identifies as female (*female*), and the wind the athlete experiences during the time of their jump (*jumpwind*). Table 7 shows results of this alternative specification. Figure 5 shows the predicted probabilities by rank across both performance measures and fixed effect specifications based on estimates from Table 7.

As seen in Table 7 and Figure 5, the pattern of the relationship between rank and performance is fairly consistent as alternative fixed effects specifications are considered. The relationship between rank and performance is U-shaped across both models. While the pattern of the relationship between rank and performance is similar across fixed effect specifications, the magnitudes vary somewhat.

Table 7: Alternative fixed effect specifications

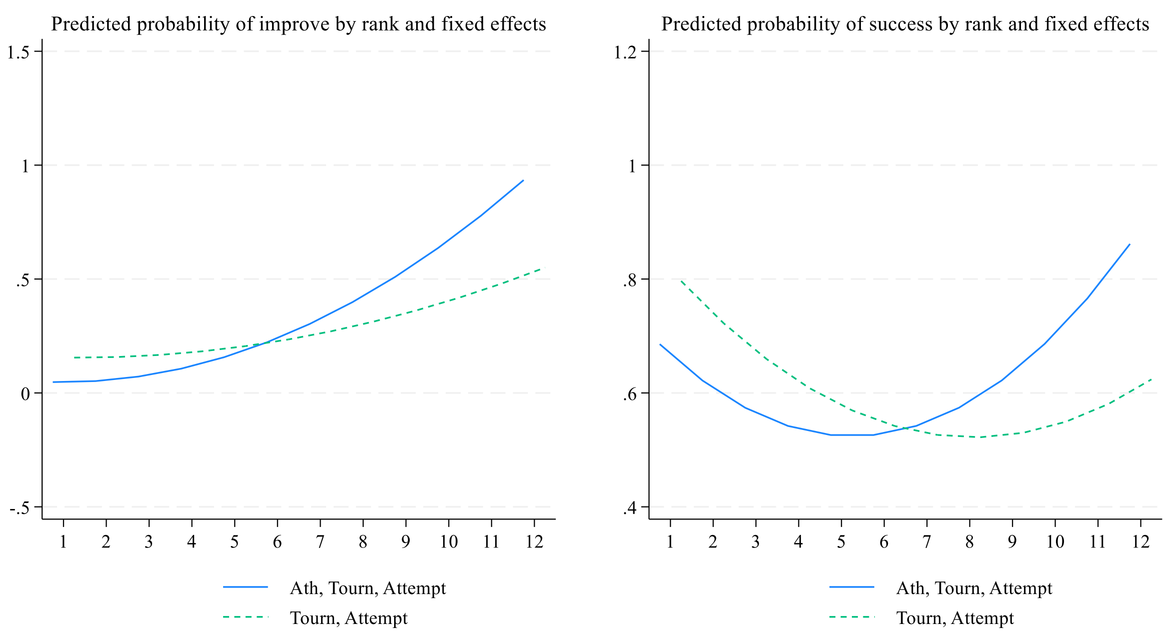
	(1)	(2)	(3)	(4)
	Improve	Improve	Success	Success
rank	-0.018	-0.007	-0.088***	-0.092***
	(0.031)	(0.021)	(0.027)	(0.021)
$rank^2$	0.008***	0.003*	0.008***	0.006***
	(0.003)	(0.002)	(0.002)	(0.002)
sb		0.260**		0.264**
		(0.118)		(0.126)
female		0.490**		0.346
		(0.195)		(0.210)
jumpwind		0.092***		0.036
		(0.022)		(0.026)
Athlete FE	Yes	No	Yes	No
Tournament FE	Yes	Yes	Yes	Yes
Attempt FE	Yes	Yes	Yes	Yes
Observations	693	693	766	766

The table displays linear probability estimates with standard errors clustered by the athlete. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Rank could also impact the probability of fouling and, as discussed previously, when an athlete fouls on a jump attempt, no distance is recorded. Our performance variables, *improve* and *success* are constructed to avoid this selection issue. As an additional robustness check, to account for the potential selection issue, we also estimate a Heckman selection model with the selection equation representing the probability of not fouling. Athletes who do not foul have a recorded distance for the jump attempt and are selected for inclusion in the main estimation relationship. The results of the Heckman selection model can then be compared to the results presented in Table

4. In order to estimate the first stage selection equation, we create the variable $bepassed_{ita}$, which is equal to 1 if at least one trailing athlete, with at least one additional upcoming attempt, has a pretournament season best that is longer than athlete *i*'s leaderboard distance during attempt *a* of tournament *t*, and 0 otherwise (note that during the 6th, and final, attempt of the tournament an athlete who has already completed their last attempt is no longer able to pass another athlete, regardless of pretournament season best). We argue that *bepassed* will likely impact the probability of fouling but should not affect either the probability of improving or the probability of success very much. For example, taking less risk (less chance of fouling) may raise the chance of making a small improvement in jump distance but lowers the chance of making a big improvement, and we anticipate that those effects will likely offset each other. Therefore, we include *bepassed* as a Heckman selection instrument in the selection equation.

Figure 5: Predicted probabilities by rank and fixed effects



The results for the two-step Heckman selection model are reported in Table 8. All variables from the main estimation model are also included in the selection equation. As expected, *bepassed* is significant in the selection equation for the probability of not fouling in every column of Table 8. The results for the main estimations in Table 8 are similar to the results in Table 4 and continue to indicate a quadratic relationship between performance and rank. For the models with rank included as a series of dummy variables, reported in columns (3) and (6), the overall results are also similar to Table 4 with some differences in the statistical significance and magnitudes of the estimated impacts of rank on performance. As expected, the inverse Mills ratio is not significant in any of the models presented in Table 8. This provides additional evidence that the results previously presented in Table 4 do not suffer from significant selection issues.

Next, we obtain separate results for females and males using model (1). The results for males are reported in Table 9 and the results for females are reported in Table 10. The results reported in Tables 9 and 10 are similar to the results reported in Table 4 and continue to indicate a quadratic relationship between performance and rank. For the models with rank included as a series of dummy variables, reported in columns (3) and (6), the results for males and females are also similar to the results reported in Table 4, with some differences in the statistical significance and magnitudes of the estimated impacts of rank on performance.

Table 8: Impact of rank on performance using Heckman selection

	(1)	(2)	(3)	(4)	(5)	(6)
main equation	Improve	Improve	Improve	Success	Success	Success
rank	0.095***	-0.029		0.034**	-0.062*	
	(0.017)	(0.035)		(0.015)	(0.032)	
rank^2		0.010***			0.007***	
		(0.003)			(0.002)	
rank 2			0.123			-0.061
			(0.126)			(0.121)
rank 3			0.185			-0.335***
			(0.119)			(0.114)
rank 4			0.189			-0.264**
			(0.139)			(0.131)
rank 5			0.215*			-0.109
			(0.120)			(0.115)
rank 6			0.240*			-0.114
			(0.140)			(0.135)
rank 7			0.315**			-0.104
			(0.144)			(0.136)
rank 8			0.526***			-0.205
			(0.142)			(0.135)
rank 9			0.728***			0.154
			(0.168)			(0.149)
rank 10			0.587***			0.189
			(0.220)			(0.191)
rank 11			0.998***			0.078
			(0.200)			(0.156)
rank 12			1.262***			0.061
			(0.287)			(0.214)
Athlete FE	Yes	Yes	Yes	Yes	Yes	Yes
Tournament FE	Yes	Yes	Yes	Yes	Yes	Yes
Attempt FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations selected	454	454	454	506	506	506

	(1)	(2)	(3)	(4)	(5)	(6)
selection equation	nofoul	nofoul	nofoul	nofoul	nofoul	nofoul
rank	0.132***	-0.057		0.136***	0.001	
	(0.034)	(0.105)		(0.029)	(0.093)	
rank^2		0.018*			0.012	
		(0.010)			(0.008)	
rank 2			0.474*			0.425
			(0.287)			(0.284)
rank 3			0.053			-0.021
			(0.296)			(0.290)
rank 4			0.637**			0.548*
			(0.318)			(0.311)
rank 5			0.276			0.268
			(0.297)			(0.288)
rank 6			0.736**			0.732**
			(0.309)			(0.301)
rank 7			0.757**			0.762**
			(0.336)			(0.314)
rank 8			0.891***			0.883***
			(0.334)			(0.311)
rank 9			0.621			0.585
			(0.477)			(0.407)
rank 10			2.042***			2.037***
			(0.690)			(0.519)
rank 11			1.639***			1.135***
			(0.556)			(0.390)
rank 12			14.488***			2.536***
			(1.482)			(0.546)
bepassed	0.345*	0.459**	0.507**	0.303*	0.404**	0.464**
	(0.189)	(0.200)	(0.213)	(0.174)	(0.188)	(0.204)
Athlete FE	Yes	Yes	Yes	Yes	Yes	Yes
Tournament FE	Yes	Yes	Yes	Yes	Yes	Yes
Attempt FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	693	693	693	766	766	766
Inverse Mills Ratio	0.375	0.169	0.089	0.161	-0.063	-0.136
	(0.258)	(0.212)	(0.189)	(0.232)	(0.207)	(0.178)

The table displays estimates from a Heckman selection model using Heckman's two-step consistent estimator. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 9: Impact of rank on performance for males

	(1)	(2)	(3)	(4)	(5)	(6)
	Improve	Improve	Improve	Success	Success	Success
rank	0.074***	-0.009		0.006	-0.092**	
	(0.013)	(0.051)		(0.013)	(0.042)	
rank^2		0.007*			0.008**	
		(0.004)			(0.004)	
rank 2			-0.131			-0.196
			(0.141)			(0.136)
rank 3			-0.048			-0.456***
			(0.145)			(0.136)
rank 4			-0.061			-0.407**
			(0.166)			(0.159)
rank 5			0.106			-0.270*
			(0.147)			(0.152)
rank 6			0.113			-0.228*
			(0.134)			(0.129)
rank 7			0.142			-0.277**
			(0.129)			(0.114)
rank 8			0.416***			-0.290**
			(0.135)			(0.120)
rank 9			0.535***			-0.135
			(0.197)			(0.197)
rank 10			0.518**			0.324**
			(0.233)			(0.160)
rank 11			0.545***			-0.179
			(0.203)			(0.195)
rank 12			0.973***			-0.120
			(0.275)			(0.264)
Athlete FE	Yes	Yes	Yes	Yes	Yes	Yes
Tournament FE	Yes	Yes	Yes	Yes	Yes	Yes
Attempt FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	348	348	348	382	382	382

The table displays linear probability estimates for males, with standard errors clustered by the athlete. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 10: Impact of rank on performance for females

	(1)	(2)	(3)	(4)	(5)	(6)
	Improve	Improve	Improve	Success	Success	Success
rank	0.057***	-0.024		0.011	-0.083**	
	(0.015)	(0.037)		(0.011)	(0.036)	
$rank^2$		0.007**			0.008***	
		(0.003)			(0.003)	
rank 2			0.268**			-0.143
			(0.114)			(0.090)
rank 3			0.287***			-0.186**
			(0.092)			(0.077)
rank 4			0.355***			-0.167
			(0.112)			(0.102)
rank 5			0.175			-0.096
			(0.108)			(0.076)
rank 6			0.305***			-0.119
			(0.100)			(0.105)
rank 7			0.374***			-0.093
			(0.116)			(0.102)
rank 8			0.404***			-0.387***
			(0.105)			(0.100)
rank 9			0.559***			0.097
			(0.178)			(0.105)
rank 10			0.553***			0.205*
			(0.200)			(0.118)
rank 11			0.987***			0.108
			(0.121)			(0.133)
rank 12			1.217***			0.137
			(0.292)			(0.148)
Athlete FE	Yes	Yes	Yes	Yes	Yes	Yes
Tournament FE	Yes	Yes	Yes	Yes	Yes	Yes
Attempt FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	345	345	345	384	384	384

The table displays linear probability estimates for females, with standard errors clustered by the athlete. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Conclusion

Using data from long jump competitions that occurred during IAAF World Championships and Olympics from 2005 to 2017, we find evidence that an athlete's interim rank in a tournament affects the athlete's performance. We find that the relationship between an athlete's performance and their interim rank is U-shaped. For athletes near the top of the leaderboard, we see that a higher rank decreases performance, but eventually, at some worse ranking, we find that a higher rank increases performance.

Using *improve* as a measure of performance, the U-shaped relationship between an athlete's performance and their interim rank is generally robust to alternative fixed effects specifications. However, the relationship between rank and improve does not appear to be quadratic for the specification with attempt fixed effects and combined athlete-tournament fixed effects. Using *success* as a measure of performance, the U-shaped relationship between an athlete's performance and their interim rank is robust to all alternative specifications considered, but the rank at which the relationship reverses occurs at different points across different models.

The long jump competitions examined in this paper are designed as rank-order tournaments where outcomes are determined according to the relative performance of the athletes. Long jump tournaments provide a nice setting to investigate whether psychological pressure impacts an athlete's performance in a rank-order tournament. Since long jump tournaments are sequential and have a common competition space with only twelve athletes in the finals, athletes have complete information about current interim rankings within the tournament. This allows us to remove information asymmetry as a potential determinant of our results. Our results add to the literature concerning how competition impacts performance and risk-taking. The results of our analysis support previous analysis demonstrating that interim rank is an important determinant of performance.

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