Interim Rank, Risk Taking, and Performance in Dynamic Tournaments

Christos Genakos

Athens University of Economics and Business and Centre for Economic Performance

Mario Pagliero

Università di Torino and Collegio Carlo Alberto

We empirically study the impact of interim rank on risk taking and performance using data on professionals competing in tournaments for large rewards. As we observe both the intended action and the performance of each participant, we can measure risk taking and performance separately. We present two key findings. First, risk taking exhibits an inverted-U relationship with interim rank. Revealing information on relative performance induces individuals trailing just behind the interim leaders to take greater risks. Second, competitors systematically underperform when ranked closer to the top, despite higher incentives to perform well. Disclosing information on relative ranking hinders interim leaders.

I. Introduction

Individuals competing in tournaments are rewarded on the basis of their relative, rather than absolute, performance. Many everyday fields of eco-

We would like to thank Cristian Bartolucci, Pascal Courty, Dino Gerardi, Giovanni Mastrobuoni, Francesca Molinari, Ignacio Palacios-Huerta, Aleksey Tetenov, Tommaso Valletti, John Van Reenen, and seminar participants at Boston University, Cambridge, Collegio Carlo Alberto, Cyprus, Dartmouth, Imperial College Business School, London School of Economics, North Carolina State University, University College London, and Universitat Pompeu Fabra for useful comments. We would especially like to thank the former head coach of the Greek weight lifting team, Christos Iakovou; the vice president of the Hellenic Weightlifting Federation, Giorgos Paraskevopoulos; and the executive director of the Queensland

[*Journal of Political Economy*, 2012, vol. 120, no. 4]

nomic activity are characterized by such a tournament-like structure. Employees and managers in labor markets, for example, are subject to relative performance evaluations within a firm; in financial markets, mutual funds compete in attracting new funds on the basis of their relative performance; in product markets, companies compete in patent races to secure the rights to new products; in schools, students and teachers may be ranked according to their relative performance; and, finally, the majority of sporting events are organized as tournaments.

An extensive literature emphasizes the role of tournaments in realigning the incentives of the parties involved (Lazear and Rosen 1981; Green and Stokey 1983; Nalebuff and Stiglitz 1983). For instance, in the labor market, a tournament among managers could provide incentive for improved effort resulting in higher performance, thus mitigating the typical inefficiencies caused by the conflicting objectives of managers and shareholders.

However, it is likely that tournaments affect not only choices concerning effort but other aspects of individual behavior as well, including risk taking and performance under pressure. In addition, tournaments are often dynamic, so the incentives generated by the competition may be different for individuals leading in the competition and those lagging behind. Individuals with a high interim rank, for example, may try to protect their position by decreasing risk taking. Those lower down in the interim rank may engage in riskier strategies in an attempt to catch up with the leaders. Exactly how agents' risk-taking behavior and performance vary depending on relative performance in previous stages of the competition is still an open question and is fundamental to our understanding of tournaments in labor, financial, and product markets. From a policy point of view, it is crucial to understand how disclosure of information on relative performance during a competition may affect participants' subsequent behavior.

An important branch of research is devoted to understanding how the behavior of individuals is affected by tournaments (Ehrenberg and Bognanno 1990; Knoeber and Thurman 1994; Chevalier and Ellison 1997; Brown 2011) and other performance evaluation schemes (Oyer 1998; Lazear 2000; Courty and Marschke 2004; Bandiera, Barankay, and Rasul 2007). Economic theory suggests that risk taking and performance depend on how information on relative performance is revealed, but the shape of the relation between interim rank, risk taking, and performance and the magnitude of these effects are empirical issues. In practice, little is known about the impact of interim rank on risk taking and performance during a dynamic tournament (Casas-Arce and Martinez-Jerez

Weightlifting Association for useful comments and advice. Grace Lee provided excellent research assistance. Financial support from the Economic and Social Research Council Centre for Economic Performance is gratefully acknowledged. The opinions expressed in this paper and any remaining errors are those of the authors alone.

2009). The main obstacle is the difficulty in separately observing both the level of risk taken by competitors and their performance during a tournament.

This paper exploits an unusually rich panel data set derived from weight lifting competitions, with individual-level information on professional athletes competing repeatedly in tournaments with substantial rewards. Weight lifting competitions are multistage tournaments with the distinctive characteristic of requiring athletes to publicly announce the amount they intend to lift at each stage. Access to these recorded announcements, together with information on whether the lift was successful or not, affords a unique opportunity to observe both the intentions and the performance of all participants.

Using a panel data set containing round-by-round information from Olympic Games and World and European Championships between 1990 and 2006, we estimate how the announced weights and the probability of a successful lift vary depending on interim rank. Since what matters for an individual's score is the amount successfully lifted (more details are given in Sec. II), higher announcements represent a riskier strategy in the sense that they imply a larger difference between the outcome in case of success or failure. Therefore, the relation between rank and announcement is informative of athletes' risk-taking behavior, while the relation between rank and the probability of a successful lift is informative of their performance.

The probability that an athlete will succeed in lifting the declared weight during a specific attempt is much less than one. This implies that interim ranking within a competition is very volatile. This variability of interim ranking provides us with an ideal environment for observing how professionals react when in the lead or when trailing other competitors. The panel dimension of the data allows us to control for multiple sources of unobserved heterogeneity at the individual, competition, and year level. The multistage nature of the games even allows us to estimate specifications in which we can control for joint individual-competition-year fixed effects.

We present two key results. First, when lagging behind, competitors tend to take greater risks than when in the lead. However, risk taking exhibits an inverted-U relationship with rank: announcements increase from first to sixth place but decrease moving further down in the rank; after rank 17, the level of risk taken is not significantly different from that for first place. The magnitude of the impact of rank is significant. A shift from first to sixth place corresponds to a 1.8 kilogram (kg) increase in announcement, which is 50 percent of the average increase in announcement between two stages.

Our results are in line with the conventional wisdom that troubled firms and interim losers in corporate tournaments are more likely to take riskier strategies than market leaders or that the trailing team in sports competitions may have a strong incentive to take greater risks. The nonmonotone relation between interim rank and risk taking is consistent with the observation that catching up with the leaders becomes progressively more unlikely as one moves down in the ranking.

Our second result is that, on average, the probability of a successful lift (conditional on the chosen weight) significantly increases when moving down in the ranking. An athlete in sixth place is at least 10 percent more likely to lift the declared weight than when he is ranked first. It seems unlikely that athletes exert less effort when ranked at the top.[1] An alternative explanation for this result is that athletes underperform under pressure, despite strong motivation and effort (Dohmen 2008; Ariely 2009; Apesteguia and Palacios-Huerta 2010). This interpretation is consistent with anecdotal evidence that athletes' performance may deteriorate as the stakes rise or when there are strong expectations for an outstanding performance. In line with the hypothesis that individuals perform badly under pressure, we show that the probability of failing to lift a given weight is higher when the competition is more intense or more prestigious.

Our work is related to a growing empirical literature on tournaments. Four key aspects distinguish our work from earlier studies. First, our paper focuses on the effects of interim rank within a tournament. The existing literature has mainly focused on the impact of the overall level of prizes or on different compensation schemes.[2] Second, most studies focus on either performance or risk taking. When they do attempt to measure risk taking, they focus on variability in performance or other output measures.[3] Differently from previous studies, we can measure risk taking separately from performance, and we can also condition for the intended strategies of participants when comparing performance.[4] Third, we use

[1] One would generally expect athletes to be more motivated and to exert greater effort when ranked at the top, where the gain from an increase in rank is highest. The positive relation between rewards, motivation, and effort seems to be accepted in the literature (Prendergast 1999), although with some exceptions (Camerer et al. 1997; Gneezy and Rustichini 2000*a*, 2000*b*; Frey and Jegen 2001; Heyman and Ariely 2004).

[2] Ehrenberg and Bognanno (1990) and Becker and Huselid (1992) use data from sports tournaments to study the link between prizes and performance. Knoeber and Thurman (1994) study the effect of different compensation schemes on the performance of broiler chicken farmers. Main, O'Reilly, and Wade (1993) and Eriksson (1999) study corporate tournaments and executive compensation.

[3] Very little evidence is available on risk-taking behavior in tournaments. Knoeber and Thurman (1994) provide some evidence that better farmers displayed less volatile performance. Brown, Harlow, and Starks (1996) and Chevalier and Ellison (1997) show that mutual funds with relatively low midyear performance increase fund volatility. Bronars and Oettinger (2001) study variability in performance in golf tournaments. Similarly, Lee (2004) studies variability in payoffs in poker tournaments, and Grund and Gürtler (2005) find that losing teams in soccer matches are more likely to make a risky substitution.

[4] Consider the case in which leaders in a multistage tournament try to protect their position by taking low-risk strategies (strategies with low payoffs but a high probability of suc-

an exceptionally rich panel data set that allows us to control for unobserved heterogeneity in greater detail than previous studies.

II. A Brief Overview of Weight Lifting Competitions and the Data

In weight lifting competitions, athletes attempt to lift heavy weights mounted on steel bars.[5] Lifters perform two types of lifts: the snatch and the clean & jerk.[6] Lifters are allowed six attempts, the first three for snatch and the remaining for clean & jerk.[7] The competition is therefore organized in six stages. Within each stage, weights are progressively loaded onto the bar and competitors attempt to lift their desired weight (called the announcement) in increasing order, from the lightest to the heaviest weight. The sequence of attempts and outcomes of the lifts are displayed publicly on an announcement board.[8]

If they are unsuccessful at a particular weight, the athletes have the option of reattempting the same lift or trying a heavier one in the following stage.[9] At the end of the competition, each athlete's highest successful lifts in the snatch and the clean & jerk are summed to determine their final scores. Athletes are then ranked, with the highest score corresponding to first place. In addition, at the end of each stage, interim rankings are computed using the same procedure.[10]

The relationship between final rank and prizes is convex, particularly at the top. The first three athletes are awarded medals and receive most of the media coverage. Private sponsorships are also offered mainly to medal winners, and gold medalists receive the lion's share of fame and recognition. National teams often provide substantial monetary rewards

cess). If the riskiness involved in such strategies is not observable to the researcher, comparing realized payoffs across individuals may not be informative about differences in effort.

[5] Weight lifting has a long history as an Olympic discipline. Men's weight lifting was on the program of the first modern Olympic Games in Athens in 1896, while the first contemporary World Championships took place in London in 1891.

[6] In the snatch, they lift the bar to arm's length above their head in one movement. In the clean & jerk, they lift the bar to their shoulders, stand up straight, and then jerk the bar to arm's length above their head.

[7] Before the start of each game, competitors are weighed and assigned an official body weight. This then determines the weight category in which they will compete. There are eight categories for men and seven for women. Athletes may switch between different categories over the course of their athletic careers. For this reason, our definition of a competitor throughout this paper is an athlete in a particular body weight category.

[8] Initial announcements are made before the beginning of the stage without knowing the announcements of the others. However, these announcements can be changed during the course of the stage, provided they do not require unloading weight from the bar. In our data set, we observe the final announcements, which correspond to the weights effectively attempted by athletes. When two athletes wish to attempt the same weight, a random lot number publicly assigned at the beginning of the competition determines the order.

[9] The weight announced in stage 3 (the last attempt in snatch) does not affect the announcement in stage 4 (the first attempt in clean & jerk).

[10] For the second and third stages, the interim rank is computed using only the best successful lift in snatch.

TABLE 1
Descriptive Statistics

	Snatch			Clean & Jerk		
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Announcement (average)	122.404	125.953	128.013	150.570	154.808	156.752
Probability of a successful lift (average)	.732	.570	.397	.806	.557	.317

Source.—Authors' calculations based on the International Weightlifting Database corresponding to round-by-round athletes' performance data for the most well-known international weight lifting competitions (the Olympic Games, World and European Championships) from 1990 to 2006.

and other benefits such as civil service jobs or employment in the national sport federation to medal winners in international competitions.[11]

Comprehensive round-by-round data for all athletes who participated in the best-known weight lifting competitions (the Olympics and the World and the European Championships) from 1990 to 2006 were obtained from the International Weightlifting Database, yielding a total of 41,550 individual stage-specific observations for 3,763 athletes. For each observation, we have information on individual announcements and outcomes, together with the overall rank at the end of the competition, as well as at the end of snatch and clean & jerk lifts.[12]

Using this information, we reconstructed the interim ranking of all athletes at each stage of the competition.[13] Table 1 provides summary statistics on announcement and frequency of successful lifts. The average announcement increases from one stage to the next by roughly 3 kg.[14] The frequency of successful lifts falls correspondingly by around 20 percent. In general, higher weights can be lifted in the clean & jerk, as reflected in the higher average announcements.

Variability of ranking, even for a given athlete within a given competition, is significant. On average, the difference between the maximum and minimum interim rank for a given individual within a competition is 6.4 positions, with the 25th percentile experiencing a change of three positions and the 75th percentile experiencing a change of eight ranks. Even very consistent weight lifters may oscillate, for example, between getting a gold and getting no medal at all.

[11] For more information on prizes, see Genakos and Pagliero (2011).

[12] The outcome of 1 percent of the observations is missing because the athlete did not attempt to lift the announced weight. Observations relating to such individuals in those specific competitions are excluded from the sample.

[13] Our algorithm to reconstruct ranking was based on the official rules of the International Weightlifting Federation. We verified the results from our algorithm against the ranking information at the end of both snatch and clean & jerk, as well as the final overall ranking.

[14] After a successful attempt, athletes are required to increase their announcements by 1 kg.

III. Empirical Framework

A key feature of weight lifting competitions is that the outcome of a specific lift is uncertain. We characterize each athlete's ability as a risk-reward frontier that maps announced weight into the probability of a successful lift. The probability of success $P_{is}(A_{is})$ of player $i = 1, \ldots, N$ in stage $s = 1, \ldots, 6$ announcing a weight A_{is} naturally decreases as the announcement increases (fig. 1). Competitors can improve the probability of a successful lift by increasing the quality and intensity of training before the competition or by achieving greater concentration/determination during the game. However, any variable affecting performance may shift the frontier, including psychological pressure, fear, or emotions in general. The choice of the announcement entails a fundamental trade-off between the gains from a higher successful lift and the costs of a higher probability of failing. A higher announcement implies a larger difference between the payoff for success and failure and constitutes a riskier strategy.[15]

Weight lifting competitions can be described by a dynamic tournament game, where the same-stage game is repeated six times. At each stage, the bar is progressively loaded, and athletes sequentially choose whether they wish to attempt the current weight or wait. Hence, at each point of the game t_s in which player i makes a decision (attempt the current weight or wait) during stage s, there is a well-defined history H_{tsi} of previous decisions and outcomes.[16] A (pure) strategy for player i is a function σ_i that assigns an action (wait or lift the current weight) to each information set in which player i makes a decision.

Our first empirical objective is estimating how the announcement decisions depend on the interim ranking. We focus on this specific aspect of the history for two reasons. First, the literature summarized in Section I suggests that interim ranking is a key determinant of risk taking in tournaments.[17] Second, interim ranking is one central piece of information that is reported by athletes to be fundamental and that is readily available throughout the competition, so our focus is consistent with how the game is actually played.

[15] For realistic values of the announcement, the probability of a successful lift, and the slope of the risk-reward frontier, increases in announcement generate gambles that are second-order stochastically dominated (in Sec. IV we discuss the magnitude of the impact of announcements on the probability of a successful lift).

[16] This includes decisions (lift, wait) and outcomes (success, failure) of all players in previous stages and for any lower admissible weight during the current stage. For example, if the current weight is 100 kg in stage 6, player i observes history H_{tsi} that includes the decisions made by all players in stages 1–5 and their outcomes, decisions and outcomes of all players in stage 6 for weights up to 99 kg, and possibly those of players with a lower lot number for 100 kg.

[17] This intuition also specifically applies to weight lifting competitions. For a simple competition with one stage only, the rules described above directly imply that interim ranking affects risk taking in equilibrium. Under some conditions, an inverse-U-shaped relationship between interim rank and risk taking naturally emerges.

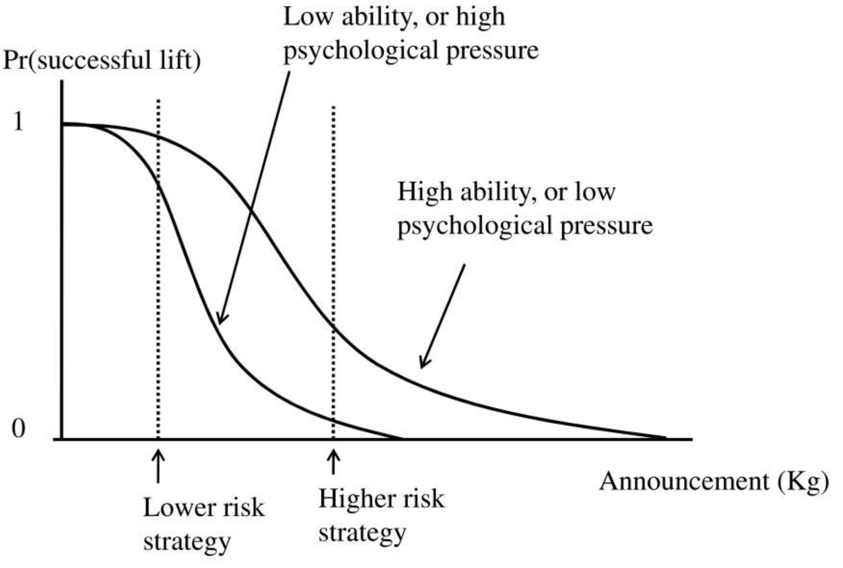

Fig. 1.—The athletes' risk-reward frontier. The figure describes the risk-reward frontiers for two hypothetical athletes of different ability. The better athlete is characterized by the frontier located to the right. Each competitor can improve the probability of a successful lift by increasing the quality and intensity of training before the competition or by having more concentration/determination during the game. Higher psychological pressure may cause choking and reduce performance.

In principle, however, the observed weight chosen by each athlete at each stage may depend on the entire history of the game up to that point. Hence, our empirical identification of the relation between interim rank and risk taking requires imposing some restrictions on what specific features of the history matter for announcements. We start by assuming that the behavior of others affects player i only through the interim ranking. We then relax this assumption by allowing history to matter in a more complex fashion, taking into account measures of proximity of athletes with similar interim scores and other variables potentially correlated with interim ranking. We also allow the relation between interim rank and risk taking to vary across individuals, competition, and stages. This is important, as individuals may have different risk-reward frontiers, competitions may have different prize levels, and competitors may react differently to changes in interim ranking depending on the stage of the competition.

The second objective of the paper is to investigate how interim ranking affects performance. We proceed in a similar way and study how the probability of a successful outcome P_{is} depends on the announcement A_{is} and on the interim ranking R_{is}. Performance may depend on interim ranking indirectly, through incentives to perform well, or directly, through the contextual and psychological effects of interim performance. The existing literature, reviewed in Section IV.D, suggests that psychological pressure at the top of the ranking may decrease performance. In interpreting the results in Section IV, we will discuss these two possible channels through which interim ranking may affect performance. As for risk taking, we will also explore other ways in which history may possibly affect performance and allow for heterogeneity across individuals, competitions, and stages.

A. *The Determinants of Announcements*

We estimate models of the following general form:

$$\begin{aligned}\text{Announcement}_{itjs} = {} & X_{itj}\beta_0 + f(\text{Rank}_{itj(s-1)},\ \beta_1) \\ & + \beta_2\text{Announcement}_{itj(s-1)} \\ & + \beta_3\text{Success}_{itj(s-1)} + e_{itjs},\end{aligned} \tag{1}$$

where $\text{Announcement}_{itjs}$ is the announcement of athlete i in year t in competition type j (a competition is classified as Olympic Game or World or European Championship) at stage s of the game ($s = 2, 3, 5, 6$);[18] X_{itj} is a vector that includes characteristics of the individual (binary indicators for country of origin and whether competing in the home country, body weight) and of the competition (e.g., number of competitors); $\text{Rank}_{itj(s-1)}$ is the ranking of athlete i in year t in competition j at the end of stage $s-1$; $f(\cdot)$ is a flexible functional form for the relation between interim rank and announcement; we require $f(\cdot)$ to be linear only in the vector of parameters β_1; $\text{Success}_{itj(s-1)}$ is a binary indicator variable that takes the value of one if the previous attempt was successful; and the random variable e_{itjs} captures the unobserved determinants of an announcement. Finally, β_2 and β_3 are scalars, whereas β_0 and β_1 are vectors of parameters to be estimated.

The model includes success in the previous round because the rules of the game dictate a minimum increase of 1 kg after a successful attempt. The level of the previous announcement is also included, as we want to allow for decreasing increments as the absolute level of the announced weight increases.[19]

[18] The first stage of snatch is dropped because the interim ranking is not defined for the first stage. In estimating model (1) we also dropped the first stage of clean & jerk because the impact of previous announcement and success may be very different during the transition from snatch to clean & jerk, which allows heavier weights to be lifted. The results, however, are not driven by the inclusion or omission of the first stage of clean & jerk.

[19] As the minimum increment after a successful attempt is 1 kg, one could rewrite model (1) as follows:

$$\begin{aligned}\text{Announcement}_{itjs} = {} & [\text{Announcement}_{itj(s-1)} + \text{Success}_{itj(s-1)}] \\ & + [X_{itj}b_0 + f(\text{Rank}_{itj(s-1)},\ b_1) \\ & + b_2\text{Announcement}_{itj(s-1)} + b_3\text{Success}_{itj(s-1)} + e_{itjs}],\end{aligned}$$

Cross-sectional estimates of model (1) will produce biased estimates of all parameters, unless one is able to control for the athletes' ability, which is likely to affect both interim ranking and announcements. Unobserved individual ability may also vary over time, as the quality of each athlete's training may vary across years or even for different competitions within the same year. Moreover, the organization of each type of competition may vary across years in ways that are unobserved to the researcher, and this may affect athletes' behavior. Hence, one needs to account for multiple sources of unobserved heterogeneity.

The error term in (1) can be thought of as the sum of athlete, year, competition, athlete-year, competition-year, athlete-competition, and athlete-year-competition components:

$$e_{itjs} = \tau_i + \tau_t + \tau_j + \tau_s + \tau_{it} + \tau_{jt} + \tau_{ij} + \tau_{itj} + \varepsilon_{itjs}, \tag{2}$$

where ε_{itjs} captures idiosyncratic shocks to the announcement decision, $\varepsilon_{itjs} \sim \mathrm{IID}(0,\ \sigma_\varepsilon^2)$. Alternative specifications are possible, depending on whether unobserved heterogeneity is thought to vary across athletes, years, type of competitions, or their interactions. In the next section, we will report the results using a number of alternative specifications for the unobserved heterogeneity.

Since unobserved heterogeneity is likely to be correlated with previous announcements, performance in previous stages, and therefore interim rank, the random-effects assumption is unlikely to be appropriate in this case. Thus, we choose to work with a fixed-effects model. Owing to the multistage nature of weight lifting competitions, we can include athlete-year-competition fixed effects (τ_{itj}). In this case, the relation between interim rank and announcement is estimated only by exploiting the variability of ranking across stages of the same competition for a given individual.

However, the existence of a lagged dependent variable in (1) implies that the fixed-effects estimator may be biased. To overcome this problem we assume that $\mathrm{Rank}_{itj(s-1)}$, $\mathrm{Announcement}_{itj(s-1)}$, and $\mathrm{Success}_{itj(s-1)}$ are predetermined; that is, they may be correlated with previous realizations of ε_{itjs}, so they may depend on unobserved determinants of the choice of the announcement in previous stages, but they are not correlated with current and future shocks to the announcement decision. Including these variables in one single vector of regressors $W_{itj(s-1)}$, we assume that $E(\varepsilon_{itjs} | \tau_{itj}, X_{itj}, W_{itj(s-1)}, W_{itj(s-2)}, \ldots, W_{itj1}) = 0$.[20]

where the first bracket is the automatic announcement, dictated by the rules of the game, and the second is the discretionary announcement, capturing athletes' risk-taking behavior. Thus, the function $f(\cdot)$ captures the impact of rank on athletes' discretionary announcement, while the parameters β_2 and β_3 in model (1) capture the joint effect on both the automatic and the discretionary announcement ($\beta_2 = 1 + b_2$; $\beta_3 = 1 + b_3$).

[20] If $f(\mathrm{Rank}_{itj(s-1)},\ \beta_1)$ is a polynomial function, then $W_{itj(s-1)}$ will include not only $\mathrm{Rank}_{itj(s-1)}$ but also its square, cube, etc., depending on the order of the polynomial.

Consider now the richest specification with athlete-year-competition fixed effects (τ_{itj}). First-differencing the model eliminates the fixed effects,

$$\Delta \text{Announcement}_{itjs} = \Delta W_{itj(s-1)}\gamma + \Delta\varepsilon_{itjs}, \tag{3}$$

and once-lagged predetermined regressors, $W_{itj(s-2)}$, are valid instruments for $\Delta W_{itj(s-1)}$, so parameters can be estimated using an instrumental variables (IV) approach (Anderson and Hsiao 1981). We also employ more efficient generalized method of moments (GMM) estimators (Arellano and Bond 1991; Blundell and Bond 1998) by taking into account all the available moment restrictions. Taking first differences and using instrumental variables also deals with the potential bias induced by the relatively short panel. The results, reported in the next section, are remarkably stable across specifications and estimation methodologies.

Finally, our specification assumes that the control variables and fixed effects in (1) capture the main determinants of risk-taking behavior. One concern could be that a higher concentration of athletes with very similar performance may affect an individual's behavior. Similarly, the absolute distance from the closest athletes (following or preceding) in the ranking may also make a difference. Risk taking may be more rewarding if an athlete leads the closest trailer by a relatively substantial amount but trails the closest leader by relatively little. We explore these issues in our robustness analysis. None of our results change in any fundamental way.

B. *The Determinants of Performance*

We estimate the impact of interim rank on performance using the linear probability model

$$\text{Success}_{itjs} = X_{itj}\delta_0 + g(\text{Rank}_{itj(s-1)},\ \delta_1) + \delta_2\text{Announcement}_{itjs} + u_{itjs}, \tag{4}$$

where Success_{itjs} is a binary indicator that takes the value of one if athlete i in year t in competition j at stage $s\,(s = 2, \ldots, 6)$ was successful in lifting the announced weight ($\text{Announcement}_{itjs}$);[21] X_{itj} is the same vector of exogenous individual and competition characteristics as before; $\text{Rank}_{itj(s-1)}$ is the interim rank of individual i in year t and competition j in the previous stage; and u_{itjs} is an error term that captures unobserved determinants of a successful lift. Our main interest is in the vector of parameters δ_1 in the flexible functional form $g(\cdot)$, which describes the impact of rank on the probability of success, controlling for announcement. As above, we require $g(\cdot)$ to be linear in the parameters δ_1. The parameter δ_2 describes the impact of announcement on the probability of a successful

[21] The first stage of snatch is dropped because the interim ranking is not defined for the first stage.

lift. In terms of figure 1, it is an estimate of the average slope of athletes' risk-reward frontier.

As before, we need to account for unobserved heterogeneity. The unobserved ability of athletes, for example, is likely to be correlated with both interim ranking and the probability of a successful lift. Thus, the random-effects assumption seems unrealistic, and we consider a fixed-effects framework. We correct for unobserved heterogeneity by extensively controlling for fixed effects. In particular, the error term in (4) can be decomposed as in (2):

$$u_{itjs} = \tau_i + \tau_t + \tau_j + \tau_s + \tau_{it} + \tau_{jt} + \tau_{ij} + \tau_{itj} + \eta_{itjs}, \tag{5}$$

where η_{itjs} describes the random component of performance, $\eta_{itjs} \sim \mathrm{IID}(0,\ \sigma_\eta^2)$.[22] This idiosyncratic component allows for random errors by the athletes or for unforeseen circumstances affecting the performance of an athlete during a lift. As above, our most general specification allows for athlete-year-competition fixed effects.

The assumption of strict exogeneity of interim rank and announcement in (4) is likely to be violated, since both variables may depend on the outcome of previous attempts.[23] We then proceed under the assumption that such variables are predetermined. Including $\mathrm{Rank}_{itj(s-1)}$ and $\mathrm{Announcement}_{itjs}$ in a single vector $Z_{itj(s-1)}$, we assume that $E(\eta_{itjs}|\tau_{itj},\ X_{itj},\ Z_{itj(s-1)},\ Z_{itj(s-2)}, \ldots, Z_{itj1}) = 0$. First-differencing model (4), we obtain

$$\Delta\mathrm{Success}_{itjs} = \Delta Z_{itj(s-1)}\theta_1 + \Delta\eta_{itjs}. \tag{6}$$

As before, lagged predetermined regressors can be used as instruments. In contrast to the results on risk taking, we will show that control-

[22] The assumption that $\eta_{itjs} \sim \mathrm{IID}(0,\ \sigma_\eta^2)$ implies that there is no correlation between η_{itjs} and ε_{itjr}. This assumption is not essential for identification, but it simplifies the analysis and is realistic in our application. The shocks η_{itjs} capture events that occur during the competition and may affect the performance of the athletes (e.g., the behavior of the public during the competition). Any variable that is fixed at the individual level for a given competition is captured by the athlete-year-competition fixed effects. Conversations with coaches and athletes indicated that athletes typically concentrate on successfully lifting the weight chosen by their coaches. Although coaches and athletes do communicate during the game, it is unlikely that the coach incorporates in the announcement decision the idiosyncratic effects captured by the error term η_{itjs}. Moreover, the variables captured by η_{itjs} are likely to be realized only during—or just before—the attempt, so they are unlikely to affect the announcement decision.

[23] The correlation between interim ranking and previous performance may give rise to an upward bias in the impact of interim rank on performance. This endogeneity problem is different from the so-called sophomore slump caused by mean reversion, a misleading result that is sometimes mentioned in the popular press. This is typically obtained by trying to explain changes in performance between periods t and $t-1$ using the level of performance in $t-1$.

ling for unobserved heterogeneity and accounting for endogeneity greatly affect the estimated impact of interim rank on performance.

The model presented in this section provides considerable computational advantages over a limited dependent variable model with endogenous explanatory variables and fixed effects. In fact, few results are available for this class of models (see Arellano and Honoré [2001] for a survey). In practice, one has to weigh the simplicity and flexibility of the linear fixed-effects framework against the obvious disadvantage that the predicted probabilities may not lie between zero and one (see Bernard and Jensen 2004). In our application, the linear model is particularly appealing because it avoids putting restrictions on the correlation between regressors and individual heterogeneity. In the next section, we provide extensive robustness analysis using alternative specifications and also a fixed-effects logit model. The results are not affected in any fundamental way.

IV. Empirical Results

A. *The Impact of Rank on Announcement*

We first explore the relationship between interim rank and announcement using a fully flexible binary-variable specification for $f(\text{Rank}_{itj(s-1)},\ \beta_1)$,

$$f(\text{Rank}_{itj(s-1)},\ \beta_1) = \sum_n \beta_{1n}\text{Rank}(n)_{itj(s-1)},$$

where $\text{Rank}(n)_{itj(s-1)}$ is an indicator variable equal to one if individual i is ranked nth at the end of stage $s-1$. Table 2 reports results for model (1) using alternative fixed-effects specifications.[24] Column 1 provides the estimated coefficients when we control for athlete, year, and competition fixed effects separately, whereas column 5 reports the estimates from our richest specification (including joint athlete-year-competition fixed effects). The omitted rank category throughout the table corresponds to the athlete ranked first, so all the rank coefficients measure the impact of being ranked nth relative to being first.

Figure 2 plots the estimated coefficients from table 2 to facilitate comparison. Two clear patterns emerge. First, when lagging behind, competitors tend to adopt riskier strategies than those in the lead. Second, risk taking exhibits an inverted-U relationship with rank: announcements increase from first to sixth place but then decrease for further decreases in rank until seventeenth place, after which there is no significant effect.

[24] Throughout the paper, we report robust standard errors clustered by athlete. All equations include stage of the competition binary indicators. Table 2 reports the coefficients of only the first 13 rank dummies; the full table is reported in the online appendix (table A1).

The relation is precisely estimated, and the alternative fixed-effects specifications provide very similar results.[25]

Table 3 reports results for model (3), where we approximate $f(\cdot)$ using a fifth-order polynomial of $\text{Rank}_{itj(s-1)}$. Column 1 reports the results obtained with the fixed-effects estimator. Column 2 reports those obtained by taking first differences to eliminate the athlete-competition-year fixed effects and then using the IV estimator (where instruments are the once-lagged regressors). Column 3 reports the results obtained from the model in first differences using the GMM estimator, which exploits all the available moment restrictions.[26] Figure 3 plots the impact of interim rank on announcement for each estimation strategy.

The inverse-U relationship between interim rank and announcement clearly emerges from all estimation strategies. Announcements increase from first to sixth place but then decrease for further decreases in rank. A change in ranking from first to somewhere between eleventh and fifteenth has no impact on an athlete's announcement. The relationship progressively flattens toward the bottom of the ranking, where changes in rank have little impact on behavior.

The nonlinear impact of interim rank on announcement is always statistically significant. Relative to the fixed-effects estimators in figure 2, accounting for endogeneity implies a more pronounced peak in the impact of rank on announcement. When ranked sixth, an athlete announces at least 1.8 kg more than when ranked first, which is 50 percent of the average increase in announcement between two stages (see table 1).

The other estimated coefficients in tables 2 and 3 are in line with expectations. Both the impact of the previous announcement and the success indicator are positive and significant, as athletes cannot decrease their announcement and must increase it after a successful attempt. Also, in columns 1–3 of table 2, we can estimate the impact of some athletes' characteristics. Being heavier (within a given category in a specific competition) implies higher announcements. This confirms a well-known fact in weight lifting that a higher body mass allows athletes to lift heavier weights. The number of competitors has a positive but very small effect on announcement.[27] Finally, competing at home does not seem to induce athletes to take greater risks, as the coefficient on Home_{itj} is never significant.

[25] Figure A1 plots the estimated coefficients and confidence interval on the 20 rank binary indicators from our most restrictive specifications in table 2, col. 5.

[26] We choose to use a smooth function $f(\cdot)$ to reduce the number of parameters to be estimated and the number of instruments. The results do not change using higher-order polynomials, and the coefficients of the sixth or higher power of $\text{Rank}_{itj(s-1)}$ are never significantly different from zero.

[27] The coefficients in table 2, col. 3, indicate that having 10 additional participants implies an average increase of 0.08 kg in announcement.

TABLE 2
THE IMPACT OF RANK ON ANNOUNCEMENT

	Dependent Variable: Announcement$_{itjs}$				
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)
Rank 2	.270***	.275***	.291***	.313***	.397***
	(.069)	(.068)	(.073)	(.079)	(.087)
Rank 3	.246***	.254***	.298***	.417***	.502***
	(.064)	(.064)	(.070)	(.081)	(.090)
Rank 4	.531***	.542***	.587***	.669***	.738***
	(.073)	(.072)	(.080)	(.089)	(.099)
Rank 5	.590***	.603***	.654***	.748***	.823***
	(.072)	(.072)	(.081)	(.091)	(.102)
Rank 6	.654***	.668***	.731***	.823***	.891***
	(.074)	(.074)	(.085)	(.092)	(.104)
Rank 7	.586***	.602***	.674***	.757***	.832***
	(.073)	(.073)	(.084)	(.092)	(.105)
Rank 8	.545***	.563***	.636***	.739***	.811***
	(.075)	(.075)	(.085)	(.094)	(.106)
Rank 9	.568***	.586***	.634***	.758***	.816***
	(.078)	(.078)	(.089)	(.096)	(.108)
Rank 10	.544***	.561***	.588***	.713***	.765***
	(.078)	(.078)	(.089)	(.097)	(.110)
Rank 11	.471***	.490***	.505***	.600***	.635***
	(.081)	(.081)	(.090)	(.099)	(.111)
Rank 12	.430***	.448***	.463***	.565***	.589***
	(.082)	(.082)	(.092)	(.103)	(.114)
Rank 13	.431***	.450***	.452***	.533***	.560***
	(.082)	(.082)	(.093)	(.103)	(.113)
Announcement$_{itj(s-1)}$	.979***	.979***	.980***	.977***	.978***
	(.002)	(.002)	(.002)	(.003)	(.003)

$Success_{itj(s-1)}$	4.170***	4.171***	4.177***	4.213***	4.209***
	(.030)	(.030)	(.032)	(.033)	(.034)
$Body\ weight_{itj}$	.014**	.014**	.016**		
	(.006)	(.006)	(.006)		
$Home_{itj}$	.010	.007	−.025		
	(.057)	(.057)	(.082)		
Number of $competitors_{itj}$	.007***	.004	.008**		
	(.003)	(.003)	(.003)		
Observations	27,700	27,700	27,700	27,700	27,700
Clusters	3,763	3,763	3,763	3,763	3,763
Athlete fixed effects	Yes	Yes			
Competition fixed effects	Yes			Yes	
Year fixed effects	Yes		Yes		
Competition-year fixed effects		Yes			
Athlete-competition fixed effects			Yes		
Athlete-year fixed effects				Yes	
Athlete-year-competition fixed effects					Yes

NOTE.—The dependent variable is the announcement by athlete i, in year t, in competition j, at stage s of the game. $Announcement_{itj(s-1)}$ is the announcement in the previous stage. $Success_{itj(s-1)}$ is success in the previous stage. Body $weight_{itj}$ is the athlete's body weight in kilograms. $Home_{itj}$ refers to competing in the home country. Number of $competitors_{itj}$ is the number of competitors at each game. All equations include stage of the competition binary indicators. Columns 1–3 also include country of origin binary indicators. The coefficients for ranks 14–20 are omitted; the full table is reported in the online Appendix (table A1). Standard errors clustered at the athlete level are reported in parentheses.

* Significant at 10 percent.

** Significant at 5 percent.

*** Significant at 1 percent.

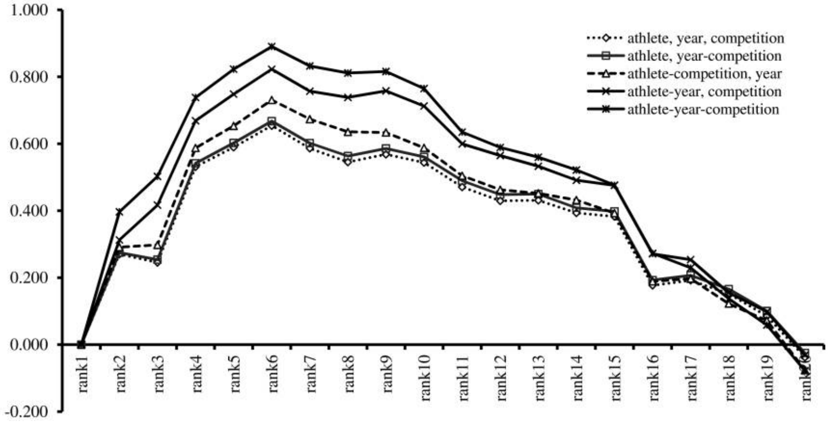

FIG. 2.—The impact of rank on announcement. The figure plots the estimated impact of rank on announcement (in kilograms). The coefficients of the binary indicators for rank positions are reported in table 2 and table A1. The different lines on the graph correspond to the five columns of table 2, where we control for different sources of unobserved heterogeneity. The omitted category always corresponds to the athlete ranked first, so all the rank coefficients measure the impact of being ranked *n*th relative to being first.

B. *Interpretation of the Impact of Rank on Announcement*

Conventional wisdom from sports competitions tells us that the trailing team may have a large incentive to adopt riskier strategies in an attempt to catch up with the leaders (Grund and Gürtler 2005). Similarly, it has been argued that troubled firms and interim losers in corporate tournaments are more likely to take riskier strategies than market leaders (Bowman 1982; Knoeber and Thurman 1994; Brown et al. 1996; Chevalier and Ellison 1997).[28] The fact that the impact of rank is positive up to rank 17 is broadly consistent with this literature.

The progressive flattening of the relation after the first six positions is also consistent with differences in risk-taking behavior at different points in the ranking.[29] Some additional details further support the link between the results in figure 2 and differences in risk-taking behavior at different positions in the ranking. If changes in the benefits deriving from risk taking drive the results in figure 2, then we expect to observe particularly large differences between the estimated coefficients at ranks 1 and 2, for while the leader has no gain from variability in rank, the second athlete may significantly gain from rank variability. We also expect to observe large differ-

[28] This intuition has been formalized by Goriaev, Palomino, and Prat (2001), Cabral (2003), and Anderson and Cabral (2007).

[29] Since rewards are decreasing at a decreasing rate going down in the ranking, the benefit from variability in rank is expected to decrease substantially toward the bottom of the ranking, where catching up with the leaders becomes progressively more unlikely.

TABLE 3
THE IMPACT OF RANK ON ANNOUNCEMENT

	Dependent Variable: $\text{Announcement}_{itjs}$		
	Fixed Effects (1)	First Difference (IV) (2)	First Difference (GMM) (3)
$\text{Announcement}_{itj(s-1)}$	.536***	.727***	.697***
	(.004)	(.006)	(.006)
$\text{Success}_{itj(s-1)}$	2.738***	3.318***	2.824***
	(.071)	(.133)	(.096)
$\text{Rank}_{itj(s-1)}$	.363***	1.539***	1.233***
	(.077)	(.177)	(.154)
$\text{Rank}^2_{itj(s-1)}$	−.045***	−.184***	−.165***
	(.009)	(.019)	(.018)
$\text{Rank}^3_{itj(s-1)} \times 10^{-2}$	.168***	.802***	.748***
	(.046)	(.092)	(.086)
$\text{Rank}^4_{itj(s-1)} \times 10^{-3}$	−.026**	−.152***	−.144***
	(.010)	(.019)	(.018)
$\text{Rank}^5_{itj(s-1)} \times 10^{-5}$	.014*	.103***	.099***
	(.008)	(.014)	(.014)
Observations	27,700	27,700	27,700
Clusters	3,763	3,763	3,763

NOTE.—The dependent variable is the announcement by athlete i, in year t, in competition j, at stage s of the game. Column 1 is estimated using athlete-year-competition joint fixed effects. The other two columns are estimated using first differences. In col. 2, we use as instruments once-lagged predetermined regressors, whereas in col. 3, we use all available moment restrictions. All equations include stage of the competition binary indicators. Standard errors clustered at the athlete level are reported in parentheses in col. 1. Windmeijer (2005) corrected robust standard errors based on a two-step estimation procedure are reported in parentheses in cols. 2 and 3.

* Significant at 10 percent.

** Significant at 5 percent.

*** Significant at 1 percent.

ences between ranks 3 and 4. In fact, prizes in weight lifting competitions display a significant discontinuity between third and fourth rank. This provides incentives to take riskier strategies when ranked fourth than when ranked third.[30]

We find strong support for these hypotheses: the coefficient for rank 2 is statistically different from zero at conventional levels (table 2, col. 5), and so is the difference in coefficients between ranks 3 and 4 ($F(1, 3{,}762) = 11.47$, p-value = .001). Moreover, the differences between ranks 1 and 2 (0.397 kg) and between ranks 3 and 4 (0.235 kg) are larger than any other difference between adjacent ranks.

[30] The discontinuity in rewards locally affects the concavity of the relation between rewards and rank, so that incentives to take risks are drastically different just above and below this threshold.

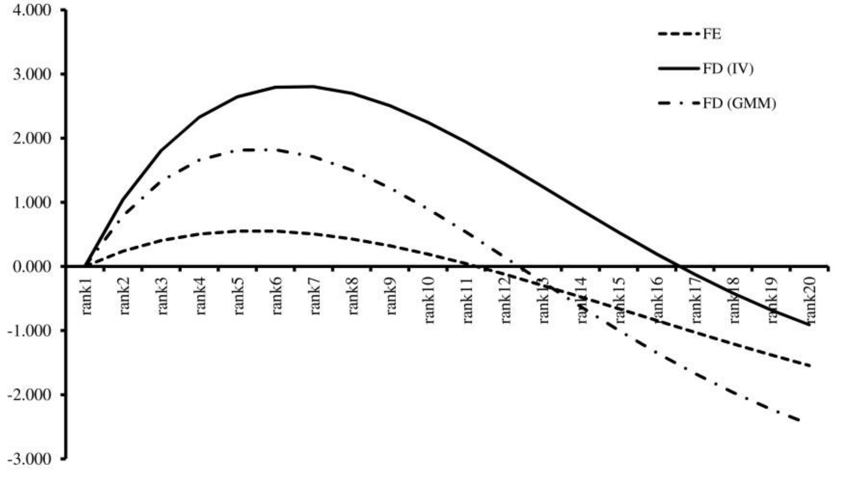

Fig. 3.—The impact of rank on announcement. The figure plots the impact of interim rank on announcement (in kilograms) based on the estimated coefficients from table 3.

Risk Taking and Absolute Distance from Competitors

The inverted-U relationship of rank on announcement observed in figure 3 remains unchanged when we control for additional variables potentially affecting risk-taking behavior. For example, we would expect athletes to take more risks and increase their announcement in an attempt to overtake their competitor if they are relatively close to the athlete just above them but relatively far from the competitor just below in the interim rank. On the contrary, we would expect athletes to reduce risk taking and try to defend their position if they are relatively far from the competitor just above but close to the competitor below in the interim rank.

For each observation, we compute the difference in score between each athlete and the athletes ranked just above and below. We then classify each observation in one of four categories and define four corresponding indicator variables: FF when a given athlete is far from both the athletes leading and following (1 percent of the observations), FC when a given athlete is far from the athlete leading but close to the athlete following (4 percent), CF in the opposite case (5 percent), and finally CC when both are close (90 percent).[31] We then use CC as the baseline category and include the remaining three indicators in model (1).

[31] We classify two athletes as being far apart if the distance between their interim scores is higher than the 95th percentile of the distribution of distances in that particular stage. We also experimented using the 90th or the 75th percentile as the cutoff. Our results qualitatively remain the same.

Results using model (3) are reported in online table A2, column 1. Announcement is 1.2 kg higher when the competitor in front is close but the trailing athlete is far (CF) relative to the baseline category but 1.2 kg lower in the opposite case (FC) and not significantly different when both are far (FF). Most importantly, the coefficients on rank imply that the pattern in figure 3 is not affected.[32] This further supports the relation between announcement decision and risk-taking behavior.

Risk Taking and Intensity of the Competition

A second concern could be that a higher concentration of athletes with similar performance might affect individuals' risk taking, as competition becomes more intense. We construct a measure of the intensity of the competition that varies at the individual level within a competition. Given the interim score s_{itjs} of athlete i in year t, competition j, and stage s, we compute the number (N_{itjs}) of athletes $k \neq i$ with interim score s_{ktjs} within a 10 kg radius: $s_{itjs} - 10 \leq s_{ktjs} < s_{itjs} + 10$. We then construct a binary indicator for tough competitions, which is equal to one when our measure of intensity of the competition is above 50 percent.[33] Table A2, column 2, reports the results from model (3) when we add the binary indicator for tough competitions. More intense competition stimulates more risk taking. Again, the pattern described in figure 3 is not affected.[34]

C. *The Impact of Rank on the Probability of a Successful Lift*

We first explore the relationship between interim rank and the probability of a successful lift using a fully flexible dummy variable specification:

$$g(\text{Rank}_{itj(s-1)},\ \delta_1) = \sum_n \delta_{1n} \text{Rank}(n)_{itj(s-1)}.$$

Table 4 reports results for model (4) using alternative fixed-effects specifications.[35] The omitted rank category corresponds to the athlete ranked first, so all the rank coefficients measure the impact of being ranked nth relative to being first. Figure 4 plots the estimated coefficients from table 4.

[32] The results are consistent with the incentives to take risk discussed in the literature (Bronars and Oettinger 2001).

[33] On average, the fraction of competitors within the 10 kg interval is 26 percent, with a median of 24 percent. So the 50 percent cutoff level captures the behavior of athletes facing relatively high concentrations of competitors around them (90th percentile). Results are robust to changes in either the radius around an athlete or the cutoff level that we use.

[34] We have also experimented by interacting the indicator for close competitions with the rank dummies and the other regressors in model (1). The results are not affected.

[35] All specifications include stage-specific dummy variables. Table 4 reports the coefficients only for the first 10 rank dummies. The full table is reported in the online appendix (table A3).

TABLE 4
THE IMPACT OF RANK ON THE PROBABILITY OF A SUCCESSFUL LIFT

	Dependent Variable: $\Pr(\text{Success})_{itjs}$				
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)
Rank 2	−.038*	−.040**	−.033	.021	.039
	(.020)	(.020)	(.022)	(.025)	(.025)
Rank 3	−.056***	−.058***	−.042*	.041	.070**
	(.022)	(.022)	(.024)	(.026)	(.028)
Rank 4	−.060***	−.062***	−.031	.068**	.131***
	(.022)	(.022)	(.025)	(.027)	(.028)
Rank 5	−.079***	−.081***	−.045*	.075***	.149***
	(.023)	(.023)	(.026)	(.027)	(.030)
Rank 6	−.051**	−.054**	−.006	.117***	.202***
	(.024)	(.024)	(.027)	(.029)	(.030)
Rank 7	−.037	−.041*	.018	.148***	.240***
	(.024)	(.024)	(.027)	(.028)	(.030)
Rank 8	−.012	−.015	.040	.173***	.269***
	(.024)	(.024)	(.027)	(.029)	(.031)
Rank 9	−.001	−.005	.061**	.207***	.310***
	(.024)	(.024)	(.027)	(.029)	(.031)
Rank 10	.015	.013	.082***	.230***	.338***
	(.025)	(.025)	(.028)	(.029)	(.031)
$\text{Announcement}_{itjs} \times$ stage 2	−.014***	−.014***	−.015***	−.021***	−.022***
	(.001)	(.001)	(.001)	(.001)	(.001)
$\text{Announcement}_{itjs} \times$ stage 3	−.013***	−.013***	−.014***	−.020***	−.021***
	(.001)	(.001)	(.001)	(.001)	(.001)
$\text{Announcement}_{itjs} \times$ stage 4	−.012***	−.012***	−.013***	−.018***	−.019***
	(.001)	(.001)	(.001)	(.001)	(.001)
$\text{Announcement}_{itjs} \times$ stage 5	−.012***	−.012***	−.013***	−.018***	−.019***
	(.001)	(.001)	(.001)	(.001)	(.001)
$\text{Announcement}_{itjs} \times$ stage 6	−.012***	−.012***	−.012***	−.017***	−.018***
	(.001)	(.001)	(.001)	(.001)	(.001)
Body weight_{itj} (in kg)	.009***	.009***	.010**		
	(.003)	(.003)	(.004)		
Home_{itj}	.073***	.074***	.103***		
	(.019)	(.019)	(.026)		
Number of competitors_{itj}	−.004***	−.005***	−.007***		
	(.001)	(.001)	(.001)		
Observations	34,625	34,625	34,625	34,625	34,625
Clusters	3,763	3,763	3,763	3,763	3,763
Athlete fixed effects	Yes	Yes			
Competition fixed effects	Yes			Yes	
Year fixed effects	Yes		Yes		
Competition-year fixed effects		Yes			
Athlete-competition fixed effects			Yes		
Athlete-year fixed effects				Yes	
Athlete-year-competition fixed effects					Yes

NOTE.—The dependent variable is a binary indicator that takes the value one if the attempt to lift a given weight by athlete i, in year t, in competition j, at stage s of the game was successful. All equations include stage of the competition binary indicators. Columns 1–3 also include country of origin binary indicators. The coefficients for ranks 11–20 are omitted; the full table is reported in the online Appendix (table A3). Standard errors clustered at the athlete level are reported in parentheses below coefficients.

* Significant at 10 percent.

** Significant at 5 percent.

*** Significant at 1 percent.

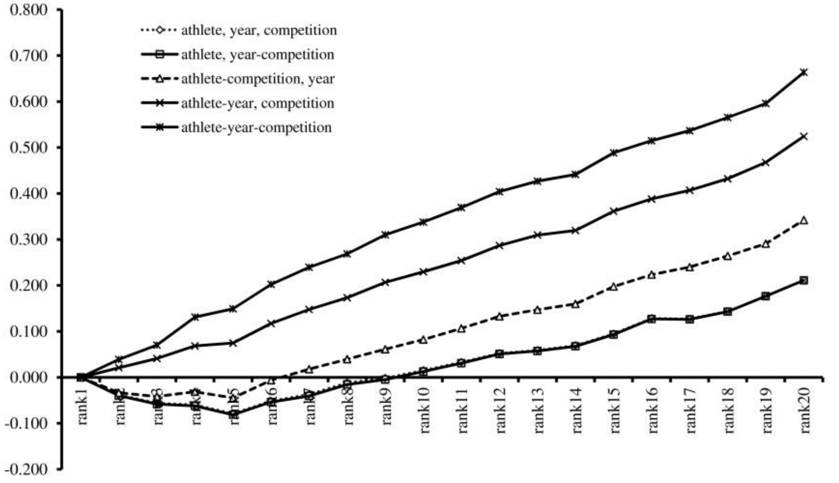

Fig. 4.—The impact of rank on the probability of a successful lift. The figure plots the estimated coefficients of the binary indicators for the rank position from table 4 and table A3. The different lines on the graph correspond to the five columns of table 4, where we control for different sources of unobserved heterogeneity. The omitted category always corresponds to the athlete ranked first, so all the rank coefficients measure the impact of being ranked *n*th relative to being first.

In sharp contrast to model (1), controlling for more sources of unobserved heterogeneity has a substantial impact on the results reported in figure 4. There is no significant correlation between interim ranking and probability of a successful lift when we control for athlete, year, and competition fixed effects separately.[36] However, as we progressively control for additional sources of unobserved heterogeneity, a positive and statistically significant relationship appears. This result is driven by an omitted variable bias. Individuals with higher ability are likely to be ranked toward the top, and they also perform better on average. When we do not control for individual characteristics, the rank variable captures the impact of differences in quality, so the performance at the top of the ranking is overestimated.[37]

As discussed in the previous section, controlling for unobserved heterogeneity is important but does not account for the possible endogeneity of $\mathrm{Rank}_{itj(s-1)}$. We expect a negative correlation between the lagged er-

[36] Some coefficients in table 4 are significantly different from zero, suggesting a negative impact of rank within a very small range, but these results are not robust.

[37] Results using the conditional (fixed-effects) logit model show the same positive relationship between rank and success (table A3, col. 6). The impact of rank on the log odds of a successful lift is positive and statistically significant.

ror term $u_{itj(s-1)}$ and $\text{Rank}_{itj(s-1)}$ since a successful lift typically implies an improvement in the interim ranking at the end of the stage (i.e., a decrease of the Rank variable). This generates a positive correlation between the change in rank $(\Delta\text{Rank}_{itj(s-1)})$ and the error term $(\Delta\eta_{itjs})$ of the model in first differences (6). Thus, we expect the fixed-effects estimator to be biased upward.

Table 5, column 1, reports the results obtained with the fixed-effects estimator, where $g(\cdot)$ is assumed to be a quadratic function of $\text{Rank}_{itj(s-1)}$.[38] Column 2 reports the results for model (6) using once-lagged predetermined regressors as instruments, whereas column 3 reports those obtained using all the available moment restrictions. Figure 5 plots the impact of interim rank on the probability of a successful lift for each estimation strategy.

There is a significant positive relationship between ranking and the probability of a successful lift, independently of the estimation strategy adopted. Conditional on the announced weight, the probability of a successful lift is at least 10 percent higher when an athlete is sixth rather than first. The relation between rank and performance is slightly concave, implying decreasing marginal effects of moving down in the ranking. The IV estimation strategies reveal that the fixed-effects estimator is indeed biased upward. The magnitude of the impact of rank is now much smaller, at least half of that obtained with the fixed-effects estimator.[39]

Finally, the results in table 5 show that the estimated impact of $\text{Announcement}_{itjs}$ is always significantly negative, as expected. Higher announcements naturally lead to a lower probability of success, as the individual risk-reward frontier is downward sloping. On average, an increase of 1 kg in the weight implies a 1.2 percent decrease in the probability of a successful lift.

D. *Interpretation of the Impact of Rank on Performance*

The results from model (4) imply that moving toward the top of the ranking decreases performance. One potential explanation for this surprising result is based on contextual/psychological effects. Athletes' performance may deteriorate when the stakes are higher, when the importance of success is higher (Baumeister 1985), or when there is more pressure from other individuals, whether friendly or not (Zajonc 1965; Baumeister,

[38] The results do not change using higher-order polynomials, and the coefficients of the third and higher powers of $\text{Rank}_{itj(s-1)}$ are never significantly different from zero.

[39] It is not worthwhile to deliberately fail an attempt, go down in the ranking, and benefit from a higher probability of a successful lift. Given the average probability of failing an attempt and the realized distribution of scores, the implied gains do not compensate the losses from forfeiting one attempt.

TABLE 5
THE IMPACT OF RANK ON THE PROBABILITY OF A SUCCESSFUL LIFT

	Dependent Variable: Pr(Success)$_{itjs}$		
	Fixed Effects (1)	First Difference (IV) (2)	First Difference (GMM) (3)
Announcement$_{itjs}$	−.012***	−.009***	−.011***
	(.001)	(.001)	(.001)
Rank$_{itj(s-1)}$	.053***	.024***	.028***
	(.002)	(.004)	(.004)
Rank$^2_{itj(s-1)} \times 10^{-3}$	−.461***	−.343***	−.381***
	(.058)	(.106)	(.104)
Observations	27,700	27,700	27,700
Clusters	3,763	3,763	3,763

NOTE.—The dependent variable is a binary indicator that takes the value one if the attempt to lift a given weight by athlete *i*, in year *t*, in competition *j*, at stage *s* of the game was successful. Column 1 is estimated using athlete-year-competition joint fixed effects. The other two columns are estimated using first differences. In col. 2 we use as instruments once-lagged predetermined regressors, whereas in col. 3 we use all available moment restrictions. All equations include stage of the competition binary indicators. Standard errors clustered at the athlete level are reported in parentheses in col. 1. Windmeijer (2005) corrected robust standard errors based on a two-step estimation procedure are reported in parentheses in cols. 2 and 3.

* Significant at 10 percent.

** Significant at 5 percent.

*** Significant at 1 percent.

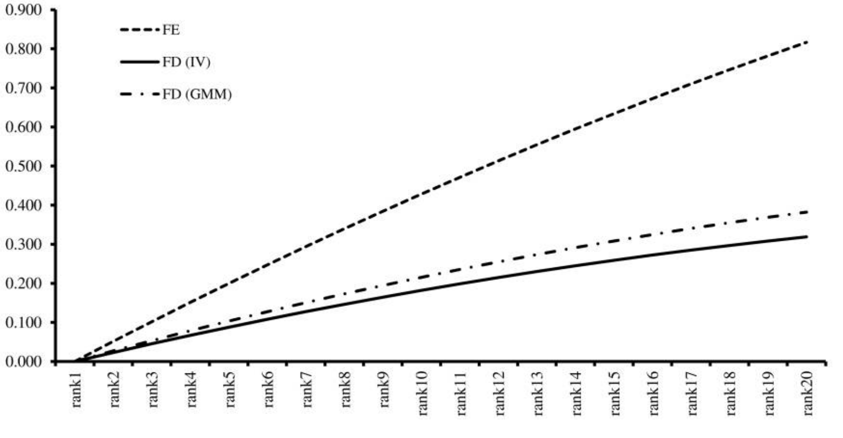

FIG. 5.—The impact of rank on the probability of a successful lift. The figure plots the impact of interim rank on the probability of a successful lift based on the estimated coefficients from table 5.

Hamilton, and Tice 1985).[40] Stakes are higher at the top of the ranking, as are the importance of a successful lift and the potential pressure created by the public and the media. This suggests that athletes may perform worse when ranked closer to the top. The coaches we interviewed reported that it is expected for athletes to perform systematically better in training sessions than in competitions, which suggests that psychological pressure may indeed be important.

Prestigious versus Nonprestigious Competitions

There is no doubt that prizes (both monetary and not) and media coverage are much higher for the Olympic Games and World Championship than for the European Championship. Thus, one would expect pressure to be higher (and hence performance to be lower) in the most prestigious competitions. Alternatively, one might expect athletes to exert more effort and perform better in more prestigious competitions. This second hypothesis is consistent with the existing literature (briefly summarized in Sec. I) linking the value of prizes in contests to competitors' effort.

We interact all explanatory variables (rank and stage binary indicators and announcement at each stage) in model (4) with a binary variable equal to one for less prestigious competitions (European Championships) and zero otherwise.[41] Table 6 reports the impact of interim rank on performance in the two types of competitions (computed for the average announcement at each stage), which are also plotted in figure 6.[42]

Performance is significantly lower in more prestigious competitions: the average difference in the two curves in figure 6 is 13 percent.[43] These

[40] The psychological literature suggests at least two reasons for which choking may occur in our setting. First, there may be an optimal level of arousal for performing a given task, beyond which increasing incentives may result in poorer performance (Yerkes and Dodson 1908). Second, increased pressure may make people unconsciously switch from automatic to controlled mental processes, in spite of the fact that automatic processes provide higher performance for some types of highly rehearsed tasks (Baumeister 1985). Sports—such as weight lifting—involving repetition of the same actions are typical cases of such tasks.

[41] The European Championships take place every year, whereas the World Championships alternate with the Olympic Games, taking place every 4 years. So there are many instances in which the same athlete can participate in both types of competition during a single year.

[42] Denote by P prestigious competitions and define the indicator variable P equal to one for prestigious competitions. Table 6 reports $\delta_n^P\ \mathrm{Rank}(n) + (1/5)\Sigma_s(\lambda_s^P \mathrm{Announcement}_s^* + \tau_s^P)$ for each rank n, both for prestigious ($P = 1$) and nonprestigious competitions ($P = 0$), where $\mathrm{Announcement}_s^*$ is the average announcement for stage s, and τ_s^P is the estimated stage-specific coefficient. Table A4 in the online appendix reports the estimated coefficients controlling for athlete-year fixed effects, which is the most restrictive specification we can use.

[43] To control for self-selection of athletes into the two types of competitions, we reestimate the same model restricting the sample to those athletes who participated in both competitions in the same year. The impact of interim rank is reported in table 6, cols. 3 and 4. The results are substantially unaffected, although the average distance between the two curves is slightly smaller (9 percent).

TABLE 6
THE IMPACT OF RANK IN PRESTIGIOUS AND NONPRESTIGIOUS COMPETITIONS

	All Athletes		Same Athletes in Both Competitions	
	Nonprestigious (1)	Prestigious (2)	Nonprestigious (3)	Prestigious (4)
Rank 1	.070*		.016	
	(.040)		(.055)	
Rank 2	.116***	.000	.055	−.010
	(.039)	(.032)	(.060)	(.066)
Rank 3	.160***	.000	.052	−.040
	(.039)	(.034)	(.059)	(.063)
Rank 4	.163***	.048	.047	−.065
	(.039)	(.036)	(.063)	(.065)
Rank 5	.165***	.059*	.050	−.028
	(.040)	(.036)	(.066)	(.062)
Rank 6	.220***	.094***	.104	−.070
	(.041)	(.037)	(.068)	(.066)
Rank 7	.255***	.122***	.126*	−.003
	(.041)	(.037)	(.070)	(.067)
Rank 8	.283***	.148***	.100	.039
	(.041)	(.037)	(.069)	(.066)
Rank 9	.315***	.183***	.157**	.054
	(.042)	(.037)	(.069)	(.070)
Rank 10	.350***	.199***	.177**	.093
	(.043)	(.037)	(.074)	(.068)
Rank 11	.362***	.230***	.197**	.055
	(.043)	(.037)	(.076)	(.069)
Rank 12	.378***	.272***	.153*	.150**
	(.045)	(.038)	(.079)	(.073)
Rank 13	.430***	.281***	.235***	.116
	(.045)	(.038)	(.083)	(.071)
Rank 14	.422***	.300***	.276***	.088
	(.048)	(.038)	(.088)	(.077)
Rank 15	.500***	.327***	.312***	.149**
	(.050)	(.038)	(.095)	(.075)
Rank 16	.487***	.369***	.221**	.185**
	(.051)	(.039)	(.091)	(.084)
Rank 17	.520***	.383***	.349***	.195**
	(.057)	(.041)	(.094)	(.081)
Rank 18	.516***	.416***	.147	.237***
	(.063)	(.040)	(.154)	(.077)
Rank 19	.566***	.448***	.167	.216**
	(.066)	(.042)	(.135)	(.090)
Rank 20	.649***	.501***	.440***	.226***
	(.052)	(.036)	(.090)	(.065)
Observations	34,625		7,385	
Clusters	3,763		523	
Athlete-year fixed effects	Yes		Yes	

NOTE.—The table reports the impact of interim rank on the probability of a successful lift for the average announcement: $\delta_n^P \text{Rank}(n) + (1/5)\Sigma_s(\lambda_s^P \text{Announcement}_s^* + \tau_s^P)$ for each rank n, for both prestigious ($P = 1$) and nonprestigious competitions ($P = 0$), where Announcement_s^* is the average announcement for stage s, and τ_s^P is the estimated stage-specific coefficient. The impact of rank 1 in prestigious competitions is normalized to zero. The estimated coefficients using athlete-year fixed effects are reported in the online Appendix (table A4). The sample size in cols. 3 and 4 is restricted to the athletes that participated in both types of games in the same year.

* Significant at 10 percent.

** Significant at 5 percent.

*** Significant at 1 percent.

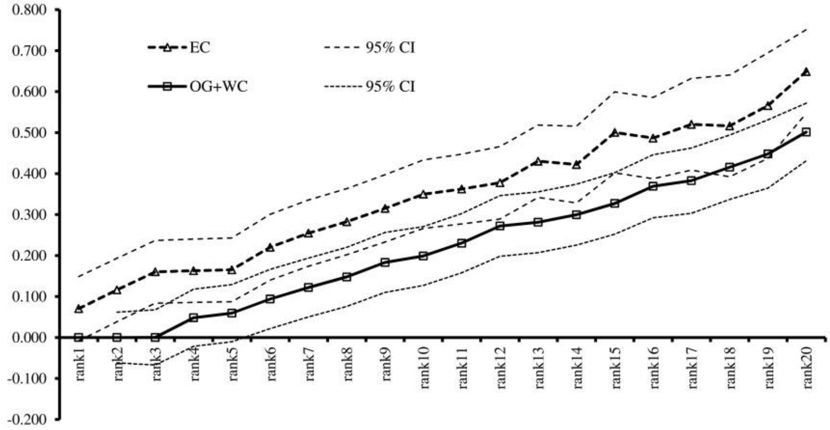

FIG. 6.—The impact of rank on the probability of a successful lift in prestigious and nonprestigious competitions. The figure plots the impact of interim rank (and the 95 percent confidence interval) on the probability of a successful lift (computed for the average announcement at each stage) in prestigious and nonprestigious competitions based on the results reported in table 6. The impact of rank 1 in prestigious competitions is normalized to zero. Estimated coefficients are reported in table A4. Calculated standard errors are clustered at the athlete level. Performance is significantly lower in prestigious competitions (joint test: $F(19, 3{,}762) = 4.14$, p-value = .000).

findings suggest that psychological pressure may indeed dominate the increased effort in important competitions. Moreover, the fact that both curves in figure 6 are upward sloping shows that the positive relation between rank and performance is robust when controlling for possible differences between the two types of competition.[44]

Tiredness

An alternative interpretation for our results could be that athletes at the top of the ranking are more fatigued, having successfully lifted heavier weights, and so their performance may decrease in subsequent attempts. We find this explanation unsatisfactory for two reasons. First, it is not necessarily the case that a successful attempt is more tiring than a failed one. Hence, it is not necessarily true that athletes are more tired when ranked at the top, since an athlete may be ranked at the bottom after a series of ambitious—yet unsuccessful—attempts. Second, we reestimate model (6) controlling for tiredness using the cumulative weight attempted in previous stages. Results from table 7, column 2 (col. 1 simply reproduces col. 3 from table 5 to ease comparison), reveal that its impact is negative but

[44] We also estimate the impact of rank on risk taking in the two types of competition, controlling for athlete-year fixed effects. We find that announcements are higher in more prestigious competitions, particularly toward the bottom of the interim ranking. Results are reported in table A5 and fig. A2.

TABLE 7
THE IMPACT OF RANK ON THE PROBABILITY OF A SUCCESSFUL LIFT: ROBUSTNESS

	Dependent Variable: $\Pr(\text{Success})_{itjs}$				
	First Differences (GMM) (1)	First Differences (GMM) (2)	First Differences (GMM) (3)	First Differences (GMM) (4)	First Differences (GMM) (5)
$\text{Announcement}_{itjs}$	−.011***	.000	−.009***	−.011***	−.012***
	(.001)	(.002)	(.001)	(.001)	(.001)
$\text{Rank}_{itj(s-1)}$	.028***	.036***	.024***	.023***	.041***
	(.004)	(.007)	(.004)	(.007)	(.005)
$\text{Rank}^2_{itj(s-1)} \times 10^{-3}$	−.381***	−.475**	−.299***	−.368***	−.616***
	(.104)	(.187)	(.103)	(.108)	(.128)
Tiredness		−.001***			
		(.000)			
Close competition			−.143***		
			(.021)		
Potential gains				.008	
				(.006)	
Observations	27,700	27,700	27,700	27,700	20,775
Clusters	3,763	3,763	3,763	3,763	3,763

NOTE.—The dependent variable is the announcement by athlete *i*, in year *t*, in competition *j*, at stage *s* of the game. Tiredness is the number of cumulative kilograms attempted. Close competition is a dummy equal to one if competitors' density within a 10 kg radius is high. Potential gains is the potential change in rank if successful. All equations include stage of the competition binary indicators. Column 1 simply reproduces col. 3 from table 5 to ease comparisons. In col. 5 we exclude from the estimation the last stage of the competition. Windmeijer (2005) corrected robust standard errors based on a two-step estimation procedure are reported in parentheses.
* Significant at 10 percent.
** Significant at 5 percent.
*** Significant at 1 percent.

small and that it leaves the impact of rank on performance virtually unchanged.[45]

The Effect of Intensity of Competition

In principle, performance at the top may decrease as a result of weaker incentives to perform well. This seems unlikely since our data refer to international competitions with substantial rewards, in which athletes are likely to exert maximum effort. Still, we try to control for possible confounding factors. If incentives are lower when competition is less intense and competition is systematically less intense at the top of the ranking, then performance may be decreasing moving toward the top of the rank-

[45] The impact of announcement drops, but this is simply a result of the high correlation between announcement and cumulative weight attempted in previous stages. The results are unchanged when including the interaction of cumulative weight and interim rank.

ing, without any psychological pressure. This hypothesis suggests controlling for intensity of the competition in model (4).[46]

We estimate model (6) including our measure of intensity of the competition (as defined in Sec. IV.B) among the regressors. The new variable depends on the previous history of the competition, so it is treated as predetermined. Table 7, column 3, reports the results. The impact of the indicator for close competitions is negative and significant. On average, being in close competition decreases the probability of a successful lift by about 14 percent.[47] Most importantly, the positive impact of interim rank on performance suggests that our results are not driven by the impact of intensity of the competition on effort.

The Potential Gains from a Successful Lift

Another potential explanation for our results is that, for a given announcement, the potential gain in rank from a successful lift may increase moving toward the bottom of the ranking, leading to an increase in an athlete's effort and performance. To measure this effect we compute for each observation the potential improvement in rank position in case of success, given the observed performance of all the other competitors.[48] As expected, we find that there is an increase in the potential gain from a successful lift as one moves toward the bottom of the ranking; however, the potential gain in rank is on average small, so that individuals at the bottom of the interim ranking are extremely unlikely to reach the top positions and be awarded significant prizes.[49]

We reestimate model (6) including this measure of potential gains among the regressors. Its impact on the level of performance is not statistically significant (table 7, col. 4). The impact of rank on performance is still positive and highly significant. Thus, the impact of rank on performance is unlikely to be caused by differences in incentives to exert effort at the top and at the bottom of the ranking.

Secured Positions

Some athletes may have secured their position before the end of the competition and hence may have little incentive to perform well. Since there

[46] The literature suggests that effort (and therefore performance) may be affected by the intensity of competition (Ehrenberg and Bognanno 1990).

[47] The impact of rank on performance remains unaffected even when we include the interaction between intensity of the competition and interim rank. The coefficient of the interaction variable is not significantly different from zero.

[48] This is equal to the athletes' expected improvement in ranking in case of successful lifts, if athletes can perfectly predict the outcome of other players' attempts.

[49] At rank 10, e.g., the average gain in case of success is 1.6 rank positions, at rank 20 it is 3.7, and at rank 35 it is 8.9.

is no penalty for not attempting the announced weight, athletes in such situations typically skip their attempt and their performance is recorded as a missing value in our data. In the raw data, there are few instances (1 percent) in which this occurred, and the corresponding observations are excluded from our sample. The issue of having secured a satisfying position is mostly relevant at the last stage of the competition. Thus, we reestimate the model, dropping the observations for the last stage. The impact of interim rank on performance is unaffected (table 7, col. 5).

V. Conclusions

We provide evidence of how risk taking and performance change depending on the interim rank position within a tournament. First, we show that professional athletes take greater risks when ranked close enough to the first athlete but then revert to safer strategies when ranked lower. This result is in line with the intuition that laggards may increase risk taking in an effort to catch up with the leaders. We also show that risk taking increases in more intense and in more prestigious competitions.

Our second set of results concerns the impact of interim rank on performance.[50] We show that performance decreases as an athlete gets closer to the top of the interim ranking. This result cannot be explained by unobserved individual-specific heterogeneity, differences in the intensity of the competition, potential gains from increased performance, or physical fatigue at different points in the interim rank. We also observe underperformance in more important competitions and when competition is more intense, suggesting that underperformance close to the top may result from psychological pressure.

Although our results suggest that information on relative performance may hamper performance by increasing psychological pressure, the identification of the exact channel through which emotions affect performance remains an open question. In addition, preferences for relative status may play a role in explaining differences between the performance of interim winners and losers.[51] Combining evidence from the field and the laboratory may shed light on these issues.[52]

[50] These results are not specific to weight lifting competitions. Genakos and Pagliero (2011) present similar results from professional athletes in competitive diving, a sport that requires a very different set of skills (agility vs. physical strength).

[51] For instance, Azmat and Iriberri (2010) and Blanes i Vidal and Nossol (2011) find that releasing information on relative performance increases performance in situations in which individuals are rewarded according to their absolute (not relative) performance.

[52] Hannan, Krishnan, and Newman (2008) provide evidence that feedback on relative performance decreases performance on average, while Eriksson, Poulsen, and Villeval (2009) find that there is no significant effect.

References

Anderson, A., and L. M. B. Cabral. 2007. "Go for Broke or Play It Safe? Dynamic Competition with Choice of Variance." *Rand J. Econ.* 38:593–609.

Anderson, T. W., and C. Hsiao. 1981. "Estimation of Dynamic Models with Error Components." *J. American Statis. Assoc.* 76:598–606.

Apesteguia, J., and I. Palacios-Huerta. 2010. "Psychological Pressure in Competitive Environments: Evidence from a Randomized Natural Experiment." *A.E.R.* 100:2548–64.

Arellano, M., and S. Bond. 1991. "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Rev. Econ. Studies* 58:277–97.

Arellano, M., and B. Honoré. 2001. "Panel Data Models: Some Recent Developments." In *Handbook of Econometrics*, edited by J. J. Heckman and E. Leamer, 3229–96. Amsterdam: North-Holland.

Ariely, D., U. Gneezy, G. Loewenstein, and N. Mazar. 2009. "Large Stakes and Big Mistakes." *Rev. Econ. Studies* 76:451–69.

Azmat, G., and N. Iriberri. 2010. "The Importance of Relative Performance Feedback Information: Evidence from a Natural Experiment Using High School Students." *J. Public Econ.* 94:435–52.

Bandiera, O., I. Barankay, and I. Rasul. 2007. "Incentives for Managers and Inequality among Workers: Evidence from a Firm-Level Experiment." *Q.J.E.* 122:729–73.

Baumeister, R. F. 1985. "Choking under Pressure: Self-Consciousness and Paradoxical Effects of Incentives on Skillful Performance." *J. Personality and Soc. Psychology* 46:610–12.

Baumeister, R. F., J. C. Hamilton, and D. M. Tice. 1985. "Public versus Private Expectancy of Success: Confidence Booster or Performance Pressure?" *J. Personality and Soc. Psychology* 48:1447–57.

Becker, B. E., and M. A. Huselid. 1992. "The Incentive Effects of Tournament Compensation Systems." *Administrative Sci. Q.* 37:336–50.

Bernard, A. B., and J. B. Jensen. 2004. "Why Some Firms Export." *Rev. Econ. and Statis.* 86:561–69.

Blanes i Vidal, J., and M. Nossol. 2011. "Tournaments without Prizes: Evidence from Personnel Records." *Management Sci.* 57:1721–36.

Blundell, R., and S. Bond. 1998. "Initial Restrictions and Moment Conditions in Dynamic Panel Data Models." *J. Econometrics* 87:115–43.

Bowman, E. H. 1982. "Risk Seeking by Troubled Firms." *Sloan Management Rev.* 23:33–42.

Bronars, S., and G. Oettinger. 2001. "Effort, Risk Taking, and Participation in Tournaments: Evidence from Professional Golf." Manuscript, Univ. Texas, Austin.

Brown, J. 2011. "Quitters Never Win: The (Adverse) Incentive Effects of Competing with Superstars." *J.P.E.* 119:982–1013.

Brown, K., W. V. Harlow, and L. Starks. 1996. "Of Tournaments and Temptations: Analysis of Managerial Incentives in the Mutual Fund Industry." *J. Finance* 51:85–110.

Cabral, L. M. B. 2003. "R&D Competition When Firms Choose Variance." *J. Econ. and Management Strategy* 12:139–50.

Camerer, C. F., L. Babcock, G. Loewenstein, and R. H. Thaler. 1997. "Labor Supply of New York City Cab Drivers." *Q.J.E.* 112:407–41.

Casas-Arce, P., and A. Martinez-Jerez. 2009. "Relative Performance Compensation, Contests and Dynamic Incentives." *Management Sci.* 55:1306–20.

Chevalier, J., and G. Ellison. 1997. "Risk Taking by Mutual Funds as a Response to Incentives." *J.P.E.* 105:1167–1200.

Courty, P., and G. Marschke. 2004. "An Empirical Investigation of Gaming Responses to Explicit Performance Incentives." *J. Labor Econ.* 22:23–56.

Dohmen, T. J. 2008. "Do Professionals Choke under Pressure?" *J. Econ. Behavior and Org.* 65:636–53.

Ehrenberg, R. G., and M. L. Bognanno. 1990. "Do Tournaments Have Incentive Effects?" *J.P.E.* 98:1307–23.

Eriksson, T. 1999. "Executive Compensation and Tournament Theory: Empirical Tests on Danish Data." *J. Labor Econ.* 17:262–68.

Eriksson, T., A. Poulsen, and M. C. Villeval. 2009. "Feedback and Incentives: Experimental Evidence." *Labour Econ.* 16:679–88.

Frey, B. S., and R. Jegen. 2001. "Motivation Crowding Theory: A Survey of Empirical Evidence." *J. Econ. Surveys* 15:589–611.

Genakos, C., and M. Pagliero. 2011. "Interim Rank, Risk Taking and Performance in Dynamic Tournaments." Notebook no. 196, Collegio Carlo Alberto, Moncalieri, Italy.

Gneezy, U., and A. Rustichini. 2000*a*. "A Fine Is a Price." *J. Legal Studies* 29:1–18.

———. 2000*b*. "Pay Enough or Don't Pay at All." *Q.J.E.* 115:791–81.

Goriaev, A. P., F. Palomino, and A. Prat. 2001. "Mutual Fund Tournament: Risk Taking Incentives Induced by Ranking Objectives." Working Paper no. 2794, Centre Econ. Policy Res., London.

Green, J. R., and N. L. Stokey. 1983. "A Comparison of Tournaments and Contracts." *J.P.E.* 91:349–64.

Grund, C., and O. Gürtler. 2005. "An Empirical Study on Risk Taking in Tournaments." *Appl. Econ. Letters* 12:457–61.

Hannan, R. L., R. Krishnan, and A. H. Newman. 2008. "The Effects of Disseminating Relative Performance Feedback in Tournament and Individual Performance Compensation Systems." *Accounting Rev.* 83:893–913.

Heyman, J., and D. Ariely. 2004. "Effort for Payment: A Tale of Two Markets." *Psychological Sci.* 15:787–93.

Knoeber, C. R., and W. N. Thurman. 1994. "Testing the Theory of Tournaments: An Empirical Analysis of Broiler Production." *J. Labor Econ.* 12:155–79.

Lazear, E. P. 2000. "Performance Pay and Productivity." *A.E.R.* 90:1346–61.

Lazear, E. P., and S. Rosen. 1981. "Rank-Order Tournaments as Optimal Labor Contracts." *J.P.E.* 89:841–64.

Lee, J. 2004. "Prize and Risk Taking Strategy in Tournaments: Evidence from Professional Poker Players." IZA Discussion Paper no. 1345, Inst. Study Labor, Bonn.

Main, B. G. M., C. A. O'Reilly III, and J. Wade. 1993. "Top Executive Pay: Tournament or Team Work?" *J. Labor Econ.* 11:606–28.

Nalebuff, B. J., and J. E. Stiglitz. 1983. "Prizes and Incentives: Towards a General Theory of Compensation and Competition." *Bell J. Econ.* 14:21–43.

Oyer, P. 1998. "Fiscal Year Ends and Non-linear Incentive Contracts: The Effect on Business Seasonality." *Q.J.E.* 113:149–85.

Prendergast, C. 1999. "The Provision of Incentives in Firms." *J. Econ. Literature* 37:7–63.

Windmeijer, F. 2005. "A Finite Sample Correction for the Variance of Linear Efficient Two-Step GMM Estimators." *J. Econometrics* 126:25–51.

Yerkes, R. M., and J. D. Dodson. 1908. "The Relation of Strength of Stimulus to Rapidity of Habit-Formation." *J. Comparative Neurology and Psychology* 18:459–82.

Zajonc, R. B. 1965. "Social Facilitation." *Science* 149:269–74.