Collegio Carlo Alberto

# Interim Rank, Risk Taking and Performance in Dynamic Tournaments

Christos Genakos
Mario Pagliero

No. 196
January 2011

Carlo Alberto Notebooks

www.carloalberto.org/working_papers

# Interim Rank, Risk Taking and Performance in Dynamic Tournaments[1]

Christos Genakos[2] and Mario Pagliero[3]

Abstract

Little is known about the effects of revealing information on relative performance during a dynamic tournament. We empirically study the impact of interim rank on risk taking and performance using data on professionals competing in tournaments for large rewards. As our data allows us to observe both the intended action and the performance of each participant, we can thus 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.

**JEL codes:** J33, J40, M50, M52.
**Keywords:** Dynamic tournaments, interim ranking, relative performance, risk taking.

[1] We would like to thank the Economic and Social Research Council for financial support, Cristian Bartolucci, Raj Chetty, Pascal Courty, Giovanni Mastrobuoni, Francesca Molinari, Tommaso Valletti, John Van Reenen, Jaume Ventura, and seminar participants at BU, Cambridge, Collegio Carlo Alberto, Cyprus, Dartmouth, Imperial College Business School, LSE, NC State University, UCL, and UPF for useful comments. We would especially like to thank the former head coach of the Greek weightlifting team, Christos Iakovou, the vice president of the Hellenic Weightlifting Federation, Giorgos Paraskevopoulos, and the executive director of the Queensland Weightlifting Association for useful comments and advice. Grace Lee provided excellent research assistance. The opinions expressed in this paper and any remaining errors are those of the authors alone.
[2] Selwyn College, University of Cambridge & Centre for Economic Performance, London School of Economics, e-mail: cg370@cam.ac.uk
[3] Università di Torino and Collegio Carlo Alberto, e-mail: Pagliero@econ.unito.it

## 1. Introduction

Individuals competing in tournaments are rewarded on the basis of their relative, rather than absolute, performance. Many everyday fields of economic 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 the individuals leading 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 varies depending on relative performance in previous stages of the competition is still an open question, and 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) and other performance evaluation schemes (Oyer, 1998; Lazear, 2000; Courty and Marschke, 2004; Bandiera, Barankay and Rasul, 2007). However, little is known about the impact of revealing information on relative performance during a dynamic tournament (Casas-Arce and Martinez-Jerez, 2009). In particular, there is no systematic evidence on how risk taking and performance are affected by interim ranking. The main obstacle is the difficulty involved in observing both the level of risk taken by competitors and their performance during a tournament.

This paper describes how both risk taking and performance change depending on interim rank position. It exploits an unusually rich panel dataset derived from weightlifting competitions, with individual level information on professional athletes competing repeatedly in tournaments with substantial rewards. These are multistage tournaments with the distinctive characteristic of requiring athletes to publically announce in advance 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 dataset 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 the individual's score is the amount successfully lifted (more details are given in Section 2), 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. Obviously, better athletes are more likely to succeed in lifting a given weight, but the outcome of a specific attempt is still unpredictable to a certain extent. Interim ranking within a competition is affected by this random component of performance and is very volatile. Even the best athletes may find themselves at the bottom of the ranking in a certain competition, due to a combination of their own bad luck and the success of their opponents. This variability of interim ranking provides us with an ideal environment for observing how professionals react when in the lead or when tailing 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 where 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 seventeen, the level of risk taken is not significantly different from first place. This implies that athletes choose riskier strategies when ranked closer to the top, reverting to progressively safer strategies when placed further down. The magnitude of the impact of rank is significant. A shift from first to sixth place corresponds to a 1.8Kg increase in announcement, which is 50 percent of the average increase in announcement between two stages (see Section 2 for a description of the rules).

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. However, this paper provides evidence of a non-monotone relation between interim rank and risk taking. This 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. This effect of ranking is surprising. One possible explanation is that athletes exert less effort when ranked at the top. However, since rewards are decreasing at a decreasing rate going down in the ranking, 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. Therefore, one would expect that the probability of lifting a given weight would increase, not decrease, when an athlete is ranked closer to the top.[4]

An alternative explanation for this result is that athletes underperform under pressure, despite strong motivation and effort (Ariely, Gneezy, Loewenstein and Mazar, 2005; Dohmen, 2008; Apesteguia and Palacios-Huerta, 2009). This interpretation is consistent with anecdotal evidence that athletes' performance may deteriorate as the stakes involved in achieving a successful lift 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 and in more prestigious

[4] The positive relation between rewards, motivation and effort seems to be accepted in the literature (Prendergast 1999), although with some exceptions (Camerer, Babcock, Lowenstein and Thaler, 1997; Gneezy and Rustichini, 2000a and 2000b; Frey and Jegen, 2001; Heyman and Ariely, 2004).

competitions. This is true even though one would generally expect higher effort and higher performance under such circumstances (Ehrenberg and Bognanno, 1990).

Are these results specific to weightlifting competitions? We also present results from professional athletes in competitive diving, a sport which requires a very different set of skills (agility versus physical strength). We find consistent evidence that professional divers underperform when close to the top of the interim ranking, despite strong motivation to succeed. As in weightlifting, we find that divers underperform when competition is more intense and in more prestigious competitions.

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 impact of interim rank within a tournament on risk taking and performance. Since the number of athletes in weightlifting competitions is large, we can describe such effects for a wide range of interim ranks (from 1st to 20th). The existing literature has mainly focused on the impact of the overall level of prizes, or on different compensation schemes.[5] 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: The strategies of the players remain unobserved and risk taking is inferred from volatility in performance.[6] Differently from previous studies, our setting permits us to observe both the intended action and the performance of each participant, and measure risk taking *separately* from performance. Not only can we study the impact of interim rank on both variables, but we can also condition for the intended strategies of

---

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

[6] 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 mid-year 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.
Finally, in a study of soccer matches, Grund and Gurtler (2005) find that losing teams are more likely to make a risky substitution (e.g., replacing a defensive player with an offensive one).

participants when comparing performance.[7] Third, we use an exceptionally rich panel dataset that allows us to control for unobserved heterogeneity in greater detail than previous studies. Finally, our results differ from those in previous studies by showing a inverse U-shaped relation between interim rank and risk taking and that performance decreases moving towards the top of the interim rank. These results could not be established without observing risk taking separately from performance.

The remainder of the paper is organized as follows. Section 2 briefly describes the structure and rules of weightlifting competitions and the data. Section 3 presents our identification strategy and the econometric framework. Section 4 reports our main results and robustness tests from weightlifting and diving competitions. Section 5 concludes and discusses some policy implications.

## 2. A brief overview of weight lifting competitions and the data

In weightlifting, competitors attempt to lift heavy weights mounted on steel bars.[8] Lifters perform two types of lifts - the snatch and the clean & jerk.[9] Lifters are allowed six attempts, three for each type of lift.[10] The competition is therefore organized in six stages. At the beginning of each stage, athletes announce how much they intend to lift by publicly writing their name and announcement on a roster.[11] Then, competitors attempt their announced lift in increasing order, from the lightest to the heaviest weight. If they are unsuccessful at a particular

[7] For example, 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 high probability of success). If the riskiness involved in such strategies is not observable to the econometrician, then comparing realized payoffs across individuals may not be informative about differences in effort.

[8] Weightlifting has a long history as an Olympic discipline. Men's weightlifting 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.

[9] 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.

[10] Two hours before the start of each game, competitors are weighed and assigned an official bodyweight. 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 bodyweight category. An athlete's bodyweight also plays a role in the event of two athletes lifting exactly the same weight; in this case, the competitor with the lower bodyweight wins.

[11] Announcements can be changed up to some time before the beginning of the stage. We observe the "final" announcements at the beginning of the stage.

weight, the athletes have the option of reattempting the same lift or trying a heavier one in the following stage. 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.[12]

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. In comparison to other sports (such as tennis or golf), direct cash prizes are small, even for the most prestigious competitions. However, national teams provide substantial monetary rewards and other benefits such as civil service jobs, or employment in the national sport federation to medal winners in international competitions.[13]

In addition to such private rewards, the top twenty-five athletes earn points for their national teams' classification. The allocation of these points is non-linear for the top three positions (the first athlete receives twenty-eight points, the second twenty-five and the third twenty-three), after which it becomes linear. Overall, the coaches and players we interviewed concur that there is a very significant drop in rewards between getting a medal and not getting one. In addition, there is a consensus that rewards generally decrease at a decreasing rate moving down in the ranking.[14]

Comprehensive round-by-round data for all athletes that participated in the most well-known weightlifting competitions (the Olympic Games and the World and European Championships)

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

[13] For the 2008 Olympic Games, the prizes provided by the American Federation were $25,200 for a gold medal, $22,500 for silver, $20,700 for bronze, by the Chinese (figures for 2004) €82,000, €73,000, €69,000, by the Italian €40,000, €25,000, €15,000, and by the Greek €190,000, €130,000 and €100,000 respectively. These figures include only monetary rewards given by national institutions, leaving out any additional benefits (such as civil service jobs and free housing), which may also be offered by some countries, such as Greece and Italy, or private sponsorships, which can be the main source of income for medalists. Some information on prizes is provided in Appendix B.

[14] In the empirical section that follows, we do not attempt to directly measure the monetary gains from a change in rank. Instead, we estimate the impact of rank on announcements and performance.

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 the type of competition, date, location, athlete's name, gender, weight category, country of origin, and bodyweight. We also have information on 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.[15]

Using this information, we reconstructed the interim ranking of all athletes at each stage of the competition.[16] Table 1 provides summary statistics on announcement and frequency of successful lifts. The average announcement increases from one stage to the next by roughly 3Kg.[17] The frequency of successful lifts falls correspondingly by around 20 percent. In general, higher weights can be lifted in the clean and jerk, as reflected in the higher average announcements.

Since the focus of our work is on the impact of interim rank on athletes' behavior, it is important to note that the 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 3 positions and the 75th percentile experiencing a change of 8 ranks. In other words, the variability in ranking is such that even very consistent weightlifters may oscillate, for example, between getting a gold and getting no medal at all.

[15] 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.

[16] 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.

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

## 3. Empirical Framework

We characterize each athlete's ability as a risk-reward frontier that describes the relationship between the announced weight and probability of success. This frontier is downward sloping for each athlete, since the probability of a successful lift naturally decreases as the announcement increases. Higher announcements increase the score difference between success and failure, and thus imply riskier strategies.

Figure 1 plots the risk-reward frontiers for two hypothetical athletes of different abilities. The better athlete is characterized by the frontier on 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 achieving greater concentration/determination during the game (i.e., by exerting more effort). Therefore, we can reinterpret the difference between the two curves as the impact of effort. Effort, however, is not the only potential explanation. Any variable affecting performance may shift the frontier, including psychological pressure, fear or emotions in general.

At each round, athletes choose their announcement, measured on the horizontal axis in Figure 1. This choice entails a fundamental trade-off between the gains from a higher successful lift and the costs of a higher probability of failing. In other words, for any given athlete, a higher announcement implies a higher probability of failure along with a higher reward for success, and a larger difference between the payoffs for success and failure. In this sense, a higher announcement implies that the athlete is pursuing a riskier strategy.[18]

In the next section, we first estimate how the choice of announcement varies depending on interim ranking (as computed at the end of the previous stage). In terms of Figure 1, our estimates will describe athletes' choice of a point on the horizontal axis. We then estimate the

[18] The interpretation of the results is the same if one considers the variance in outcomes, instead of the absolute difference. For realistic values of the announcement and the probability of success, increases in announcement also correspond to increases in the (weighted) variance of outcomes.

probability of a given individual successfully lifting the announced weight, and how this varies with ranking. In terms of Figure 1, our estimates will describe how athletes' risk-reward frontiers change as ranking varies.

### 3.1. The Determinants of Announcements

We estimate models of the following general form:

$$Announcement_{itjs} = X_{itj}\,\beta_0 + f(Rank_{itj(s-1)}, \beta_1) + \\ + \beta_2\,Announcement_{itj(s-1)} + \beta_3\,Success_{itj(s-1)} + e_{itjs} \qquad (1)$$

where $Announcement_{itjs}$ is the announcement of athlete $i$, in year $t$, in competition type $j$ (a competition is classified as Olympic Game, World or European Championship), at stage $s$ of the game (s=2,3,5,6)[19]; $X_{itj}$ is a vector that includes characteristics of the individual (binary indicators for country of origin and whether competing in the home country, bodyweight) and of the competition (number of competitors), $Rank_{itj(s-1)}$ 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 only require $f(\cdot)$ to be linear in the vector of parameters $\beta_1$; $Success_{itj(s-1)}$ is a binary indicator variable that takes the value of one if the previous attempt was successful; the random variable $e_{itjs}$ captures all of the unobserved determinants of an announcement. Finally, $\beta_2$, $\beta_3$ are scalars, whereas $\beta_0$ and $\beta_1$ 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

[19] 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.

also included, as we want to allow for decreasing increments as the absolute level of the announced weight increases.[20]

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 econometrician, and this may impact 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, athlete-year-competition components,

$$e_{itjs} = \tau_i + \tau_t + \tau_j + \tau_s + \tau_{it} + \tau_{jt} + \tau_{ij} + \tau_{itj} + \varepsilon_{itjs} \qquad (2)$$

where $\varepsilon_{itjs}$ captures idiosyncratic shocks to the announcement decision, $\varepsilon_{itjs}$~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. Due to the multi-stage nature of weightlifting competitions, we can include athlete-year-competition

---

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

$$Announcement_{itjs} = [Announcement_{itj(s-1)} + Success_{itj(s-1)}] + [X_{itj}\, b_0 + f(Rank_{itj(s-1)}, b_1) + b_2\, Announcement_{itj(s-1)} + b_3\, Success_{itj(s-1)} + e_{itjs}],$$

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 $f(.)$ captures the impact of rank on athletes' discretionary announcement, while the parameters $\beta_2$ and $\beta_3$ in model (1) capture the joint effect on both the automatic and the discretionary announcement ($\beta_2=1+b_2$; $\beta_3=1+b_3$).

fixed effects ($\tau_{itj}$). 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 $Rank_{itj(s-1)}$, $Announcement_{itj(s-1)}$, and $Success_{itj(s-1)}$ are predetermined, i.e., they may be correlated with previous realizations of $\varepsilon_{itjs}$, 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 $E(\varepsilon_{itjs} | \tau_{itj}, X_{itj}, W_{itj(s-1)}, W_{itj(s-2)},\ldots, W_{itj1})=0$.[21]

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

$$\Delta Announcement_{itjs} = \Delta W_{itj(s-1)}\gamma + \Delta\varepsilon_{itjs}. \quad (3)$$

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 IV approach (Anderson and Hsiao, 1981). We also employ more efficient 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

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

athletes with very similar performance may affect an individual's behavior. Similarly, the absolute distance from the closest athletes (following or proceeding) 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.

### 3.2. The Determinants of Performance

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

$$Success_{itjs} = X_{itj}\,\delta_0 + g(Rank_{itj(s-1)}, \delta_1) + \delta_2\,Announcement_{itjs} + u_{itjs} \tag{4}$$

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,...,6)[22] was successful in lifting the announced weight ($Announcement_{itjs}$), $X_{itj}$ is the same vector of exogenous individual and competition characteristics as before, $Rank_{itj(s-1)}$ is the interim rank of individual $i$, in year $t$ and competition $j$, in the previous stage; $u_{itjs}$ is an error term that captures unobserved determinants of a successful lift. Our main interest is in the vector of parameters $\delta_1$ 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 $\delta_1$. The parameter $\delta_2$ describes the impact of announcement on the probability of a successful 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. Unobserved athletes' ability, 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):

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

$$u_{itjs} = \tau_i + \tau_t + \tau_j + \tau_s + \tau_{it} + \tau_{jt} + \tau_{ij} + \tau_{itj} + \eta_{itjs} \quad (5)$$

where $\eta_{itjs}$ describes the random component of performance, $\eta_{itjs}$~IID$(0,\sigma_\eta^2)$.[23] 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.[24] We then proceed under the assumption that such variables are predetermined. Including $Rank_{itj(s-1)}$ and $Announcement_{itjs}$ 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

$$\Delta Success_{itjs} = \Delta Z_{itj(s-1)}\, \theta_1 + \Delta\eta_{itjs} \quad (6)$$

As before, lagged pre-determined regressors can be used as instruments. In contrast to the results on risk taking, we will show that controlling for unobserved heterogeneity and accounting for endogeneity greatly affects 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 Honorè, 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

---

23 The assumption that $\eta_{itjs}$~IID$(0,\sigma_\eta^2)$ implies that there is no correlation between $\eta_{itjs}$ and $\varepsilon_{itjr}$. This assumption is not essential for identification, and could be relaxed, but it simplifies the analysis and is realistic in our application. The shocks $\eta_{itjs}$ 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 which is fixed at the individual level, for a given competition, is captured by the athlete-year-competition fixed effects. Discussions 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 $\eta_{itjs}$. Moreover, the variables captured by $\eta_{itjs}$ are likely to be realized only during – or just before – the attempt, so they are unlikely to affect the announcement, which is made at the beginning of the stage.

24 For example, the correlation between interim ranking and previous performance may potentially give rise to an upward bias in the impact of interim rank because of mean reversion. Hence, it is important to deal explicitly with the potential endogeneity of interim ranking.

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.

## 4. Empirical Results

### 4.1 The Impact of Rank on Announcement

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

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

where $Rank(n)_{itj(s-1)}$ is an indicator variable equal to one if individual $i$ is ranked $n^{th}$ at the end of stage $s\text{-}1$. Table 2 reports results for model (1) using alternative fixed effects specifications.[25] 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 $n^{th}$ 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

[25] Throughout the paper, we report robust standard errors clustered by athlete. All equations include stage of the competition binary indicators. Table 2 reports only the coefficients of the first thirteen rank dummies; the full table is reported in Appendix 1 (Table A1).

until seventeenth place, after which there is no significant effect. The relation is precisely estimated and the alternative fixed effects specifications provide very similar results.[26]

Table 3 reports results for model (3), where we approximate *f(.)* using a fifth order polynomial of $Rank_{itj(s-1)}$. 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.[27] 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 11th and 15th has no impact on an athlete's announcement strategy. The relationship progressively flattens towards the bottom of the ranking, where changes in rank have little impact on behavior.

The non-linear 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 1.8Kg 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 Table 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.

[26] Figure A1 plots the estimated coefficients and confidence interval on the twenty rank binary indicators from our most restrictive specifications in Table 2, column 5.

[27] We choose to use a smooth function *f(.)* 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 $Rank_{itj(s-1)}$ are never significantly different from zero.

Also, in the first three columns 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 weightlifting that a higher body mass allows athletes' to lift heavier weights. The number of competitors has a positive, but very small effect on announcement.[28] Finally, competing at home does not seem to induce athletes to take greater risks, as the coefficient on $Home_{itj}$ is never significant.

### 4.2 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 Gurtler, 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, Harlow and Starks, 1996, Chevalier and Ellison, 1997).[29] The fact that the impact of rank is positive up to rank seventeen 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. Since rewards are decreasing at a decreasing rate going down in the ranking, the benefit from variability in rank is expected to decrease substantially towards the bottom of the ranking, where catching up with the leaders becomes progressively more unlikely.

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

[28] Coefficients from columns 1 indicate that having ten additional participants implies an average increase of 0.06 Kg in announcements.
[29] This intuition has been formalized by Cabral (2003), Goriaev, Palomino and Prat (2003), and Anderson and Cabral (2007).

large differences between the estimated coefficients at ranks one and two. 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 differences between rank 3 and 4. In fact, prizes in weightlifting competitions display a significant discontinuity between 3rd and 4th rank.[30] This provides incentives to take riskier strategies when ranked 4th than when ranked 3rd.[31]

We find strong support for these hypotheses: the coefficient for rank two is statistically different from zero at conventional levels (Table 2, column 5), and so is the difference in coefficients between rank three and four.[32] Moreover, the differences between rank one and two (0.397 Kg), and three and four (0.235 Kg), are larger than any other difference between adjacent ranks.

*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

[30] See Section 2 and Appendix B.
[31] 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.
[32] $F(1, 3762)=11.47$, p-value=0.001.

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).[33] We then use CC as the base line category, and include the remaining three indicators in model (1). Results using model (3) are reported 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, while 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. The results are consistent with the incentives to take risk discussed in the literature (Bronars and Oettinger, 2001). 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 which 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 10Kg 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.[34] Table A2, column 2 reports the results from model (3) when we add the binary indicator for tough competitions.

[33] We classify two athletes being far apart if the distance between their interim scores' is higher than the ninety-fifth percentile of the distribution of distances in that particular stage. We also experimented using the ninetieth or the seventy-fifth percentile as the cut-off. Our results qualitatively remain the same.

[34] On average, the fraction of competitors within the 10Kg interval is twenty-six percent, with a median of twenty-four percent. So the fifty percent cut-off 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 cut-off level that we use.

More intense competition stimulates more risk taking. Again, the pattern described in Figure 3 is not affected.[35]

### 4.3 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,

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

Table 4 reports results for model (4) using alternative fixed effects specifications.[36] The omitted rank category corresponds to the athlete ranked first, so all the rank coefficients measure the impact of being ranked $n^{th}$ relative to being first. Figure 4 plots the estimated coefficients from Table 4.

In sharp contrast to model (1), controlling for more sources of unobserved heterogeneity has a substantial impact. 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. However, as we progressively control for more 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 towards 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. Results using the conditional (fixed-effects) logit model show the same positive relationship between rank and success (Table A3, column 6). The impact of rank on the log-odds of a successful lift is positive and statistically significant.

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

As discussed in the previous section, controlling for unobserved heterogeneity is important but does not account for the possible endogeneity of $Rank_{itj(s-1)}$. We expect a negative correlation between the lagged error term $u_{itj(s-1)}$ and $Rank_{itj(s-1)}$, 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 ($\Delta Rank_{itj(s-1)}$) and the error term ($\Delta \eta_{itjs}$) of the model in first differences (6). Thus, we expect the fixed effects estimator to be biased upwards.

Table 5, column 1 reports the results obtained with the fixed effects estimator, where *g(.)* is assumed to be a quadratic function of $Rank_{itj(s-1)}$.[37] Column 2 reports the results for model (6) using once-lagged pre-determined 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 upwards. The magnitude of the impact of rank is now much smaller, at least half of that obtained with the fixed effects estimator.[38]

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

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

of success, as the individual risk-reward frontier is downward sloping. On average, an increase of 1Kg in the weight implies a 1.2 percent decrease in the probability of a successful lift.

### 4.4 Interpretation of the impact of rank on performance

The results from model (4) imply that moving towards the top of the ranking decreases performance. There are two potential explanations for this surprising result. First, individuals exert less effort as they move towards the top of the ranking. Although the marginal increase in rewards from an increase in rank is higher at the top, one cannot exclude that effort might decrease. In principle, this could occur (a) because competition is systematically less intense at the top, in the sense that differences in interim score across athletes are larger, (b) because the potential increase in ranking deriving from a successful lift is smaller at the top, (c) because athletes at the top are more tired, or (d) because athletes at the top may have secured their position, after having observed the performance of athletes lifting before them.[39]

A second potential explanation is that athletes' performance may deteriorate when the stakes are higher, or the importance of success is higher (Baumeister, 1985), or when there is more pressure from other individuals, whether friendly or not (Zajonc, 1965; Baumeister, Hamilton and Tice, 1985).[40] At the top of the ranking stakes are higher 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.

[39] One extreme case is when, at the last stage, the athlete in the lead has already secured a gold medal (i.e., he is the last to make his attempt and no athlete has lifted a higher weight).

[40] The psychological literature suggests at least two reasons why 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 – like weightlifting – involving repetition of the same actions are typical cases of such tasks.

The results in Figure 5 are consistent with both explanations. Ranking affects behavior, but one cannot identify whether the decrease in performance at the top comes from lower effort or choking under pressure, or a combination of both. However, there are circumstances in which the two explanations can be distinguished. This is what we study next.

*The effect of intensity of competition*

If effort is lower when competition is less intense, and competition is systematically less intense at the top of the ranking, then performance may be decreasing moving towards the top of the ranking, without any psychological pressure. This hypothesis suggests controlling for intensity of the competition in model (4).[41]

We estimate model (6) including our measure of intensity of the competition (as defined in Section 4.2) among the regressors. The new variable depends on the previous history of the competition, so it is treated as predetermined. Table 6, column 2 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.[42] The fact that athletes underperform when competition becomes more intense runs counter to the effort hypothesis. 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*

The second potential explanation for our results is that, for a given announcement, the potential gain in rank from a successful lift may increase moving towards the bottom of the ranking, leading to an increase in athlete's effort and performance. To measure this effect we compute for each observation the potential improvement in rank position in case of success,

---

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

[42] 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.

given the observed performance of all the other competitors.[43] As expected, we find that there is an increase in the potential gain from a successful lift as one moves towards the bottom of the ranking, but 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.[44]

We then re-estimate model (6) including this measure of potential gains among the regressors. Its impact on the level of performance is not statistically significant (Table 6, column 3). 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.

*The impact of tiredness on performance*

One might argue that athletes at the top of the ranking could be 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 control for tiredness using the cumulative weight attempted in previous stages. Results from Table 6, column 4 reveal that its impact is negative but small, and that it leaves the impact of rank on performance virtually unchanged.[45]

---

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

[44] At rank 10, for example, the average gain in case of success is 1.6, at rank 20 it is 3.7, while at rank 35 it is 8.9 rank positions.

[45] The impact of announcement drops, but this is simply due to 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.

*Secured positions*

Some athletes may have secured their position before the end of the competition. Since there 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 re-estimate the model, dropping the observations for the last stage. The impact of interim rank on performance is unaffected (Table 6, column 5).

*Prestigious versus non-prestigious 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. In addition, this difference is particularly pronounced for top ranking athletes than for low ranking ones, who do not receive significant prizes, nor any media coverage in either type of competition. Thus, one would expect athletes to exert more effort and perform better in more prestigious competitions, and particularly when ranked closer to the top.

To explore this hypothesis, 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.[46] Table 7 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.[47]

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

[47] Denote by $P$ prestigious competitions and define the indicator variable $P$ equal to one for prestigious competitions. Table 7 reports $\delta_n^P Rank(n)+(1/5)\Sigma_s\ (\lambda_s^P Announcement^*_s+\tau_s^P)$ for each rank $n$, both for prestigious ($P=1$) and non-prestigious competitions ($P=0$), where $Announcement^*_s$ is the average announcement for stage $s$, and $\tau_s^P$ is the estimated stage-specific

Performance is significantly lower in more prestigious competitions: the average difference in the two curves in Figure 6 is 13 percent.[48] These 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.[49]

*Diving competitions, the role of announcements and external validity*

Is the effect of interim rank on performance solely a weightlifting phenomenon? We investigate the external validity of the results by looking at competitive diving. Competitive diving shares most of the features that make weightlifting competitions attractive as a research laboratory. First, they are multistage tournaments, interim ranking is precisely computed at each stage, and variability in interim ranking is significant. Second, the intentions of competitors are clearly indicated, since divers announce in advance the dives they intend to perform.[50] Third, performance is clearly measured and publicly reported.[51]

However, diving differs from weightlifting in two important ways. First, each athlete's entire dive list is announced before the beginning of the competition. No changes are allowed. This feature simplifies the analysis of the impact of interim rank on performance, since

---

coefficient. Table A4 in the Appendix reports the estimated coefficients controlling for athlete-year fixed effects, which is the most restrictive specification we can use.

[48] To control for self-selection of athletes into the two types of competitions, we re-estimate the same model, this time restricting the sample to those athletes who participated in both competitions in the same year. The impact of interim rank is reported in Table 7, columns 3 and 4. The results are substantially unaffected, although the average distance between the two curves is slightly smaller (9 percent).

[49] 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 towards the bottom of the interim ranking. Results are reported in Table A4 and Figure A2.

[50] Each dive is identified by an alphanumeric code and a degree of difficulty. Athletes must precisely execute the movements required for the announced dives.

[51] Seven judges evaluate each dive. After deleting the two highest and the two lowest scores for each dive, the remaining scores are summed to determine the overall score of each dive. Then, dive-specific scores are summed to determine the ranking.

announcements cannot respond to any shock which occurs during the competition.[52] Second, competitive diving requires a completely different set of abilities than weightlifting (agility vs. strength), which makes it an interesting test for the external validity of our previous results on the effect of rank on performance.

We collected data on international competitions (Olympic Games, World and European Championships, and Champions Cup) between 1988 and 2009. We observe a total of 6,868 dives, their exact description and their degree of difficulty, the score obtained, the interim and final rankings, and the name and country of origin of each diver (see Appendix B for details).

We estimate

$$Score_{itjs} = X_{itj}\,\delta_0 + g(Rank_{itj(s-1)}, \delta_1) + \delta_2\,Difficulty_{itjs}, + \tau_{itj} + u_{itjs} \qquad (7)$$

where $Score_{itjs}$ is the score obtained by athlete $i$, in year $t$, competition $j$, and stage $s$, $Difficulty_{itjs}$ is the degree of difficulty for the specific dive performed, and $Rank_{itj(s-1)}$ describes the interim ranking. We estimate equation (7) as above, treating $Rank_{itj(s-1)}$ as a pre-determined regressor.[53] Table 8, column 1 reports the results using athlete-year-competition fixed effects. In the next two columns we take first differences and use first an IV approach, using $Rank_{itj(s-2)}$ as instrument for $\Delta Rank_{itj(s-1)}$ (column 2), and then a GMM approach exploiting all the available moment restrictions (column 3).[54] Figure 7 describes the estimated impact of interim rank on performance in diving competitions. Once again, the impact of ranking on performance is positive and statistically significant. The magnitude of the impact is also substantial: a shift from first to tenth place implies an increase in score of at least 6.5, which is 45 percent of the standard deviations of the score distribution.

---

[52] On the other hand, we cannot estimate the impact of interim rank on the difficulty of the chosen dives, since they are fixed for a given competition.

[53] Because of the rules of diving competitions, we can now treat the announced difficulty as an exogenous variable (but the results are not affected if we assume it is just predetermined).

[54] The results do not change using higher order polynomials and the coefficients of the second or higher power of $Rank_{itj(s-1)}$ are never significantly different from zero. Results are not affected when we use dive-specific dummies instead of the degree of difficulty.

The impact of interim rank is not affected when accounting for differences in intensity of the competition, potential gains, tiredness and overall prestige of the competition. The results, reported in Table 9, are consistent with the results in Table 6 obtained from data on weightlifting. Performance decreases when competition is more intense (Table 9, column 1), the potential gains from a perfectly executed dive increase (column 2), after a series of more difficult dives (column 3), and in more prestigious competitions (Table A6 and Figure A3). Overall, the results from diving competitions show that our results do not depend on the type of task performed by competitors, on the timing of announcements, or on whether the performance measure is discrete or continuous.

## 5. 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. This result has implications for the choice of whether to reveal information on relative performance. For instance, it is typical for firms to periodically observe measures of managers' performance, in order to measure individual productivity and possibly implement incentive schemes aimed at stimulating effort. However, our results show that workers may respond to information on relative performance by changing the riskiness of their actions, thus disrupting the relation between effort and performance on which simple compensation schemes are often based. Since risk taking is typically unobservable, a firm may withhold information on relative performance to reduce the unobserved heterogeneity across workers' strategies.

We also show that risk taking increases when competition is more intense (and in more prestigious competitions). Although this is likely to be optimal in a sporting contest, where spectators seek excitement and breathtaking performances, it may not necessarily be so desirable within firms. If firm profitability is affected more by average performance than by the rare exceptional performance of a few individuals, then increasing the intensity of the competition may reduce overall performance and profitability. On the other hand, in industries in which research and development are fundamental, this may provide workers with the optimal incentives to take risks. This may partly explain why contracts based on relative performance are common but not ubiquitous, and why they are not uniformly distributed across different types of workers, firms or industries.

Our second set of results concerns the impact of interim rank on performance. 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, by 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. This may explain why coping with pressure is often mentioned as an important skill for managers, or why contractual agreements may provide a safety net for individuals with relatively low performance. We obtain very similar results using data from competitive diving, a sport organized according to similar rules, but based on different skills.

Our findings on underperformance at the top imply that the organizer of a tournament may withhold information on relative performance in order to avoid its heterogeneous impact on interim leaders and losers. For instance, a professor may withhold information on relative performance during the academic year in order to reduce pressure on the most promising students. On the other hand, providing information on relative performance may be a way to handicap interim leaders and keep the competition open. In sporting competitions, it may be optimal to reveal interim ranking and let interim leaders deal with the additional pressure generated by the media and the public, thus making the result of the competition less certain.[55]

Although our results suggests that information on relative performance may hamper performance by increasing psychological pressure, the identification of the exact role played by emotions 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.[56] Combining evidence from the field and from the laboratory may shed light on these issues.[57]

[55] At least in principle, the tournament organizer may even provide false information on relative performance, for example understating the performance of interim leaders. An interesting issue then is how participants may factor in such a possibility.

[56] For instance, Blanes i Vidal and Nossol (2009), and Azmat and Iriberri (2010) find that releasing information on relative performance increases performance in situations in which individuals are rewarded according to their absolute (*not relative*) performance.

[57] Hannan et al. (2008) provide evidence that feedback on relative performance decreases performance on average, while Eriksson et al. (2009) find that there is no significant effect.

**Bibliography**


Anderson, A. and L. Cabral, (2007), "Go for Broke or Play it Safe? Dynamic Competition with Choice of Variance", *Rand Journal of Economics*, 38, 593-609.

Anderson, T.W., and C. Hsiao, (1981), Estimation of Dynamic Models with Error Components, *Journal of the American Statistical Association*, 76, 598-606.

Apesteguia, J. and I. Palacios-Huerta, Psychological Pressure in Competitive Environments: Evidence from a Randomized Natural Experiment (2010), *American Economic Review,* forthcoming.

Arellano, M., and S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", *Review of Economic Studies*, 58, 277-297.

Arellano, M. and Honorè (2001), "Panel data Models: Some Recent developments", Ch. 53 in Heckman and E. Leamer, eds., *Handbook of Econometrics*, North-Holland, Amsterdam.

Ariely, D., Gneezy, U., Loewenstein, G. and Mazar, N. (2005), "Large Stakes and Big Mistakes", *Review of Economic Studies*, 76, 2, 451-469.

Azmat, G. and N. Iriberri (2010), "The Importance of Relative Performance Feedback Information: Evidence from a Natural Experiment using High School Students", *Journal of Public Economic*s, 2010, 94 (7-8), 435-452.

Bandiera, O. I. Barankay and I. Rasul (2007), "Incentives for Managers and Inequality Among Workers: Evidence from a Firm-Level Experiment", *Quarterly Journal of Economics*, forthcoming.

Baumeister, R.F., (1985), "Choking under pressure: self-consciousness and paradoxical effects of incentives on skilful performance", *Journal of Personality and Social Psychology*, 46, 610–620.

Baumeister, R.F., Hamilton, J., Tice, D.M., (1985), "Public versus private expectancy of success: Confidence booster or performance pressure?", *Journal of Personality and Social Psychology*, 48, 1447–1457.

Becker, B., and M. Huselid (1992), "The Incentive Effects of Tournament Compensation Systems," *Administrative Science Quarterly*, 37, 336–350.

Bernard, A.B., and J.B. Jensen (2004), "Why Some Firms Export", *Review of Economics and Statistics*, 86, 2, 561-569.

Blanes i Vidal, J. and M. Nossol (2009), "Tournaments without Prizes: Evidence from Personnel Records", mimeo, London School of Economics.

Blundell, R. and S. Bond (1998), "Initial Restrictions and Moment Conditions in Dynamic Panel Data Models", *Journal of Econometrics*, 87, 115-143.

Bowman, E. H. (1982), "Risk Seeking by Troubled Firms", *Sloan Management Review*, Summer, 33-42.

Bronars, S. and G. Oettinger (2001), "Effort, Risk Taking, and Participation in Tournaments: Evidence from Professional Golf", *mimeo: University of Texas at Austin*.

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

Cabral, L. (2003), "R&D Competition When Firms Choose Variance", *Journal of Economics and Management Strategy*, 12, 139-150.

Camerer, Colin F., Linda Babcock, George Loewenstein, and Richard H. Thaler (1997), "Labor Supply of New York City Cab Drivers," *The Quarterly Journal of Economics*, CXII (May), 407-441.

Casas-Arce, P. and A. Martinez-Jerez (2009), "Relative Performance Compensation, Contests and Dynamic Incentives", *Management Science*, 55, 1306-1320.

Chevalier, J. and G. Ellison, (1997), "Risk Taking by Mutual Funds as a Response to Incentives," *Journal of Political Economy*, 105, 1167–1200.

Courty, P. and G. Marschke (2004), “An empirical Investigation of Gaming Responses to Explicit Performance Incentives,” *Journal of Labor Economics*, 22(1), 23-56.

Dohmen, T. J., (2008), “Do Professionals Choke under Pressure?” *Journal of Economic Behavior & Organization*, vol. 65(3-4), pages 636-653, March.

Ehrenberg, R., and Boganno, M. (1990), “Do Tournaments Have Incentive Effects?” *Journal of Political Economy*, 98(6), 1307-1323.

Eriksson, T. (1999), “Executive Compensation and Tournament Theory: Empirical Tests on Danish Data”, *Journal of Labor Economics*, 17, 2, 262-280.

Eriksson, T., A. Poulsen, and M.C. Villeval (2009), “Feedback and Incentives: Experimental Evidence”, *Labour Economics*, 16, 679-688.

Frey, B. S. and Jegen, R. (2001), “Motivation Crowding Theory: A Survey Of Empirical Evidence”, *Journal of Economic Surveys*, Vol. 15, No. 5, pp. 589-611.

Goriaev, A., Palomino, F., and Prat, A. (2003), “Mutual Fund Tournament: Risk taking Incentives Induced by Ranking Objectives”, *CEPR Discussion Papers*, No. 2794

Green, J. and N. Stokey (1983), “A Comparison of Tournaments and Contracts“, *Journal of Political Economy*, 91, 349-365.

Gneezy, U. and A. Rustichini (2000a), “Pay enough or don't pay at all,” *The Quarterly Journal of Economics*, CXV (August 2000a), 791-810.

Gneezy, U. and A. Rustichini (2000b), “A fine is a price,” *Journal of Legal Studies*, XXIX (January), 1-18.

Grund, C., and O. Gürtler (2005), “An Empirical Study on Risk Taking in Tournaments”, Applied Economics Letters, 12, 457–461

Hannan, R. L., R. Krishnan, and A. Newman (2008) “The Effects of Disseminating Relative Performance Feedback in Tournament and Individual Performance Compensation Systems”, *The Accounting Review*, 83(4), 893-913.

Heyman, J. and D. Ariely (2004), “Effort for Payment: A Tale of Two Markets,” *Psychological Science*, Forthcoming.

Knoeber, C. and W. Thurman (1994), “Testing the Theory of Tournaments: An Empirical Analysis of Broiler Production”, *Journal of Labor Economics*, 12:2, pp. 155–79.

Lazear, E. (2000), “Performance Pay and Productivity,” *American Economic Review*, 90(5), 1346-1361.

Lazear, E., and S. Rosen (1981), “Rank Order Tournaments as Optimal Labor Contracts,” *Journal of Political Economy*, 89(5), 841–864.

Lee, J. (2004), “Prize and Risk Taking Strategy in Tournaments: Evidence from Professional Poker Players”, *IZA Discussion Paper 1345*.

Main , B., O'Reilly III, C., and Wade, J. (1993), “Top Executive Pay: Tournaments or Team Work?”, *Journal of Labor Economics,* Vol. 4, pp. 606-628.

Nalebuff, B.J., and Stiglitz, J.E. (1983), “Prizes and Incentives: Towards a General Theory of Competition and Compensation”, *The Bell Journal of Economics*, Vol. 14, No. 1, 21-43.

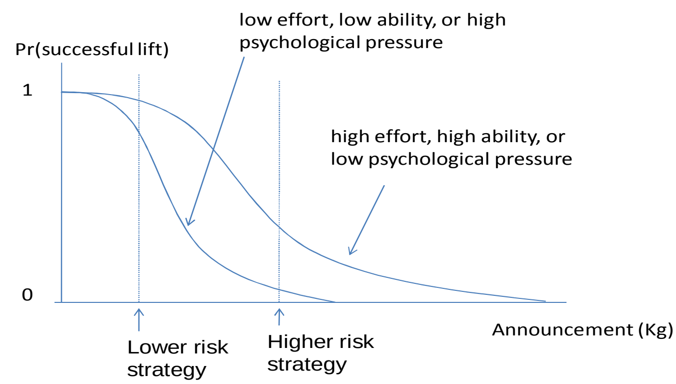
Oyer, P. (1998), “Fiscal Year Ends and Non-Linear Incentive Contracts: The Effect on Business Seasonality”, *Quarterly Journal of Economics*, 113, 149-185.

Prendergast, C. (1999), “The Provision of Incentives in Firms”, *Journal of Economic Literature*, Vol. XXXVII, 7-63.

Yerkes, R. and J. Dodson (1908), “The relationship of Strength of Stimulus to Rapidity of Habit-Formation”, *Journal of Comparative Neurology of Psychology*, 18(5), 459-482.

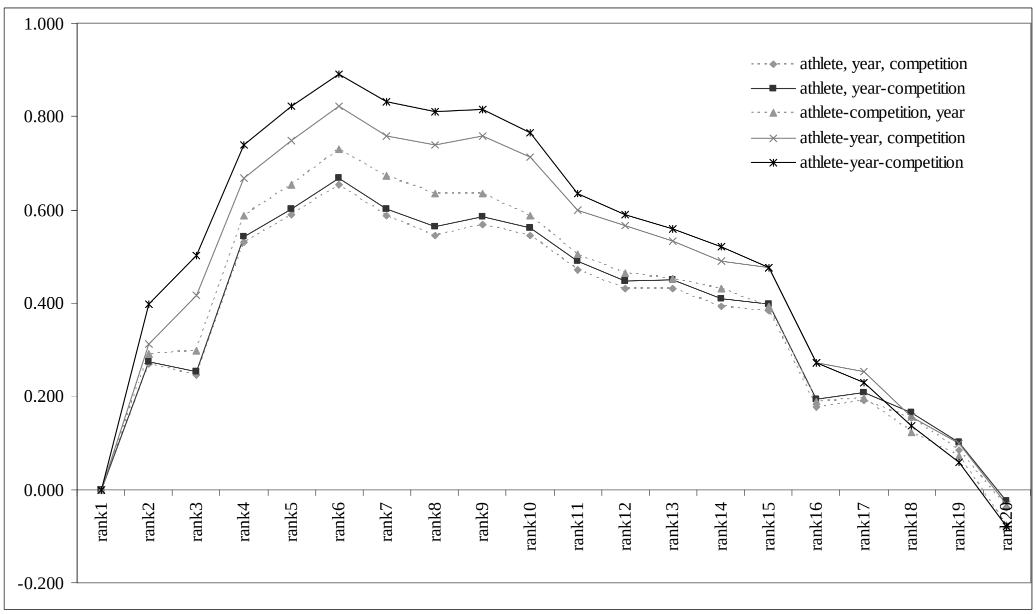
Zajonc, B. (1965), “Social Facilitation”, *Science*, 149, 269-274.

FIGURE 1 – THE ATHLETES' RISK-REWARD FRONTIER



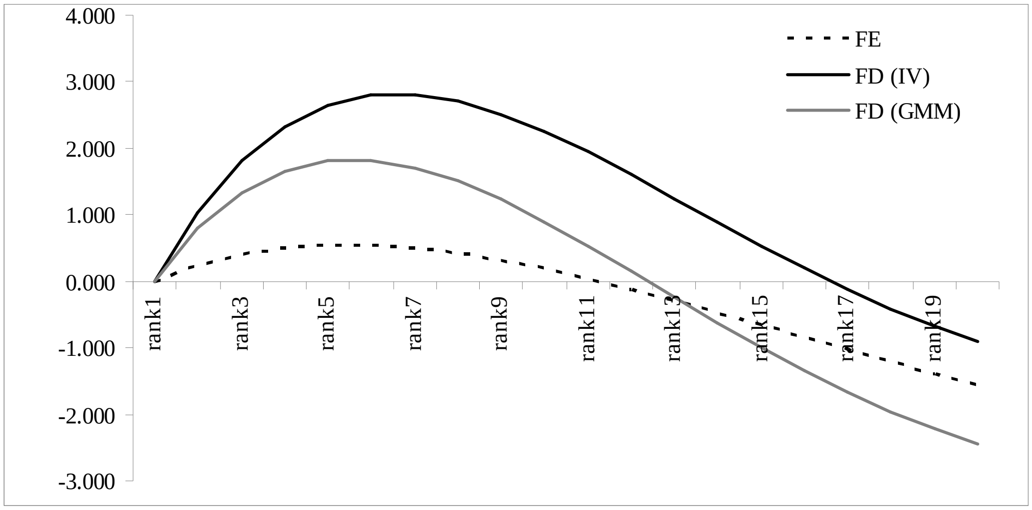

Notes: The figure describes the risk-reward frontiers for two hypothetical athletes of different ability. The better athlete is characterized by the frontier located to the right. Each competitor can improve the probability of a successful lift by increasing the quality and intensity of training before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

FIGURE 2 – THE IMPACT OF RANK ON ANNOUNCEMENT



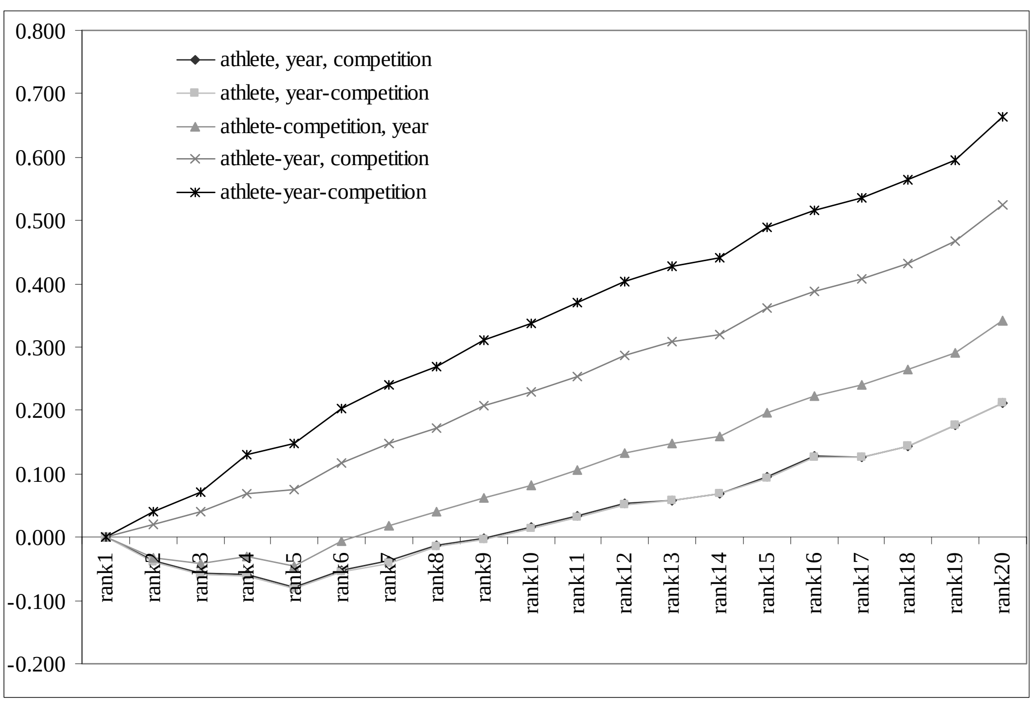

Notes: The figure plots the estimated impact of rank on announcement (Kg). The coefficients of the binary indicators for rank positions are reported in Table 2 and Table A1. The different lines on the graph correspond to the five columns of Table 2, where we control for different sources of unobserved 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.

FIGURE 3 – THE IMPACT OF RANK ON ANNOUNCEMENT



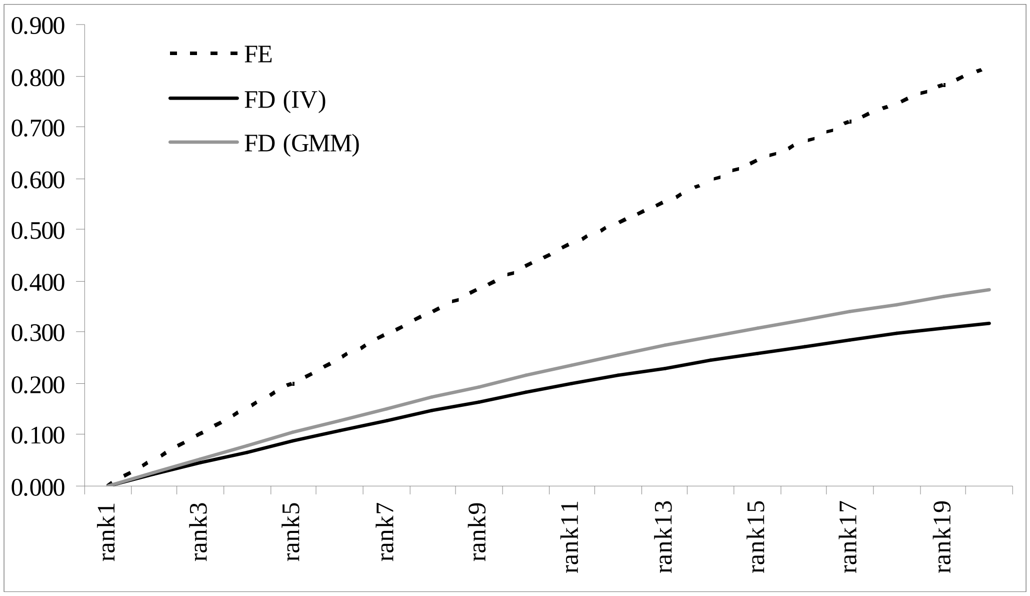

Notes: The figure plots the impact of interim rank on announcement (Kg) based on the estimated coefficients from Table 3.

FIGURE 4 – THE IMPACT OF RANK ON THE PROBABILITY OF A SUCCESSFUL LIFT



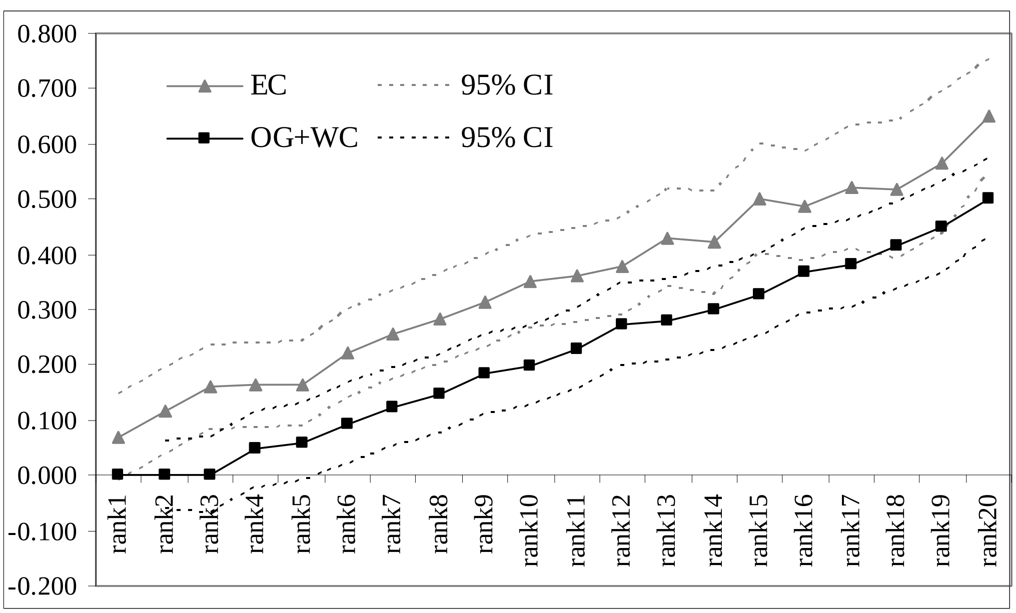

Notes: The figure plots the estimated coefficients of the binary indicators for the rank position from Table 4 and Table A3. The different lines on the graph correspond to the five columns of Table 4, where we control for different sources of unobserved heterogeneity. The omitted category always corresponds to the athlete ranked first, so all the rank coefficients measure the impact of being ranked $n^{th}$ relative to being first.

FIGURE 5 – THE IMPACT OF RANK ON THE PROBABILITY OF A SUCCESSFUL LIFT



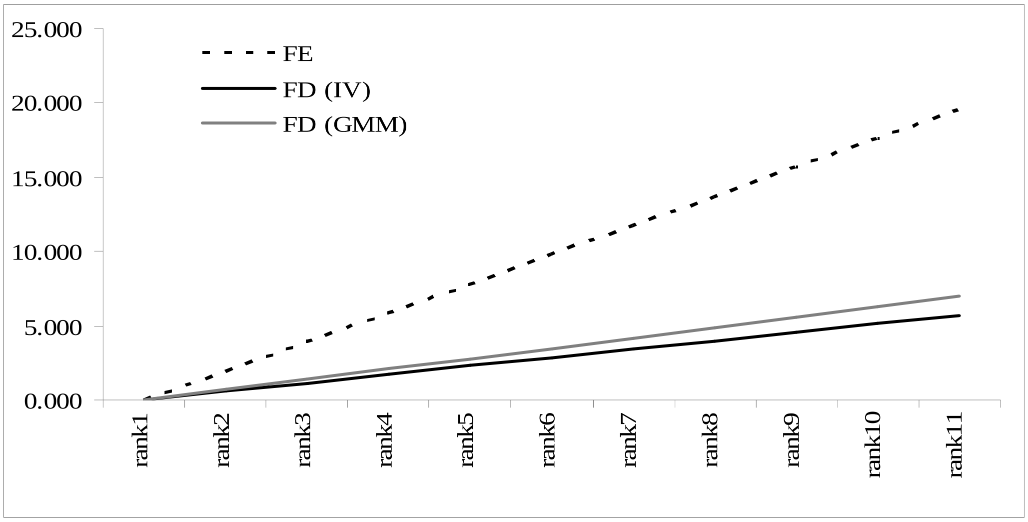

Notes: The figure plots the impact of interim rank on the probability of a successful lift based on the estimated coefficients from Table 4.

FIGURE 6 – THE IMPACT OF RANK ON THE PROBABILITY OF A SUCCESSFUL LIFT IN PRESTIGIOUS AND NON-PRESTIGIOUS COMPETITIONS




Notes: The figure plots the impact of interim rank (and the 95% confidence interval) on the probability of a successful lift (computed for the average announcement at each stage) in prestigious and non-prestigious competitions based on the results reported in Table 7. The impact of rank one 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, 3762)=4.14, p-value=0.000).

FIGURE 7 – THE IMPACT OF INTERIM RANK ON PERFORMANCE IN COMPETITIVE DIVING




Notes: The figure plots the impact of interim rank on the score achieved based on the estimated coefficients from Table 8.

TABLE 1 - DESCRIPTIVE STATISTICS

| | Snatch | | | Clean & Jerk | | |
|---|---|---|---|---|---|---|
| | stage 1 | stage 2 | stage 3 | stage 4 | stage 5 | stage 6 |
| **Announcement**<br>average announcement | 122.404 | 125.953 | 128.013 | 150.570 | 154.808 | 156.752 |
| **Prob. of Success**<br>average probability of a successful lift | 0.732 | 0.570 | 0.397 | 0.806 | 0.557 | 0.317 |

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

TABLE 2 - THE IMPACT OF RANK ON ANNOUNCEMENT

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Estimation method | OLS | OLS | OLS | OLS | OLS |
| Dependent variable | $Announcement_{itjs}$ | $Announcement_{itjs}$ | $Announcement_{itjs}$ | $Announcement_{itjs}$ | $Announcement_{itjs}$ |
| **Rank 2** | 0.270*** | 0.275*** | 0.291*** | 0.313*** | 0.397*** |
| | (0.069) | (0.068) | (0.073) | (0.079) | (0.087) |
| **Rank 3** | 0.246*** | 0.254*** | 0.298*** | 0.417*** | 0.502*** |
| | (0.064) | (0.064) | (0.070) | (0.081) | (0.090) |
| **Rank 4** | 0.531*** | 0.542*** | 0.587*** | 0.669*** | 0.738*** |
| | (0.073) | (0.072) | (0.080) | (0.089) | (0.099) |
| **Rank 5** | 0.590*** | 0.603*** | 0.654*** | 0.748*** | 0.823*** |
| | (0.072) | (0.072) | (0.081) | (0.091) | (0.102) |
| **Rank 6** | 0.654*** | 0.668*** | 0.731*** | 0.823*** | 0.891*** |
| | (0.074) | (0.074) | (0.085) | (0.092) | (0.104) |
| **Rank 7** | 0.586*** | 0.602*** | 0.674*** | 0.757*** | 0.832*** |
| | (0.073) | (0.073) | (0.084) | (0.092) | (0.105) |
| **Rank 8** | 0.545*** | 0.563*** | 0.636*** | 0.739*** | 0.811*** |
| | (0.075) | (0.075) | (0.085) | (0.094) | (0.106) |
| **Rank 9** | 0.568*** | 0.586*** | 0.634*** | 0.758*** | 0.816*** |
| | (0.078) | (0.078) | (0.089) | (0.096) | (0.108) |
| **Rank 10** | 0.544*** | 0.561*** | 0.588*** | 0.713*** | 0.765*** |
| | (0.078) | (0.078) | (0.089) | (0.097) | (0.110) |
| **Rank 11** | 0.471*** | 0.490*** | 0.505*** | 0.600*** | 0.635*** |
| | (0.081) | (0.081) | (0.090) | (0.099) | (0.111) |
| **Rank 12** | 0.430*** | 0.448*** | 0.463*** | 0.565*** | 0.589*** |
| | (0.082) | (0.082) | (0.092) | (0.103) | (0.114) |
| **Rank 13** | 0.431*** | 0.450*** | 0.452*** | 0.533*** | 0.560*** |
| | (0.082) | (0.082) | (0.093) | (0.103) | (0.113) |
| **$Announcement_{itj(s-1)}$** | 0.979*** | 0.979*** | 0.980*** | 0.977*** | 0.978*** |
| announcement in previous stage | (0.002) | (0.002) | (0.002) | (0.003) | (0.003) |
| **$Success_{itj(s-1)}$** | 4.170*** | 4.171*** | 4.177*** | 4.213*** | 4.209*** |
| success in previous stage | (0.030) | (0.030) | (0.032) | (0.033) | (0.034) |
| **$Bodyweight_{itj}$** | 0.014** | 0.014** | 0.016** | | |
| athlete's bodyweight (in Kg) | (0.006) | (0.006) | (0.006) | | |
| **$Home_{itj}$** | 0.010 | 0.007 | -0.025 | | |
| competing in home country | (0.057) | (0.057) | (0.082) | | |
| **Number of $Competitors_{itj}$** | 0.007*** | 0.004 | 0.008** | | |
| competitors at each game | (0.003) | (0.003) | (0.003) | | |
| Observations | 27700 | 27700 | 27700 | 27700 | 27700 |
| Clusters | 3763 | 3763 | 3763 | 3763 | 3763 |
| Athlete FE | yes | yes | | | |
| Competition FE | yes | | | yes | |
| Year FE | yes | | yes | | |
| Competition-Year FE | | yes | | | |
| Athlete-Competition FE | | | yes | | |
| Athlete-Year FE | | | | yes | |
| Athlete-Year-Competition FE | | | | | yes |

Notes: The dependent variable is the announcement by athlete $i$ , in year $t$ , in competition $j$ , at stage $s$ of the game. All equations include stage of the competition binary indicators. The first three columns also include country of origin binary indicators. The coefficients for ranks 14-20 are omitted; the full table is reported in Appendix A (Table A1). Standard errors clustered at the athlete level are reported in parentheses: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 3 - THE IMPACT OF RANK ON ANNOUNCEMENT

| | (1) | (2) | (3) |
|---|---|---|---|
| Estimation method | FE | FD (IV) | FD (GMM) |
| Dependent variable | Announcement $_{itjs}$ | Announcement $_{itjs}$ | Announcement $_{itjs}$ |
| **Announcement**$_{itj(s-1)}$ | 0.536*** | 0.727*** | 0.697*** |
| announcement in previous stage | (0.004) | (0.006) | (0.006) |
| **Success**$_{itj(s-1)}$ | 2.738*** | 3.318*** | 2.824*** |
| success in previous stage | (0.071) | (0.133) | (0.096) |
| **Rank**$_{itj(s-1)}$ | 0.363*** | 1.539*** | 1.233*** |
| | (0.077) | (0.177) | (0.154) |
| **Rank**$^{2}_{itj(s-1)}$ | -0.045*** | -0.184*** | -0.165*** |
| | (0.009) | (0.019) | (0.018) |
| **Rank**$^{3}_{itj(s-1)}$ **(x 10$^{-2}$)** | 0.168*** | 0.802*** | 0.748*** |
| | (0.046) | (0.092) | (0.086) |
| **Rank**$^{4}_{itj(s-1)}$ **(x 10$^{-3}$)** | -0.026** | -0.152*** | -0.144*** |
| | (0.010) | (0.019) | (0.018) |
| **Rank**$^{5}_{itj(s-1)}$ **(x 10$^{-5}$)** | 0.014* | 0.103*** | 0.099*** |
| | (0.008) | (0.014) | (0.014) |
| Observations | 27700 | 27700 | 27700 |
| Clusters | 3763 | 3763 | 3763 |

Notes: The dependent variable is the announcement by athlete *i* , in year *t* , in competition *j* , at stage *s* of the game. The first column is estimated using athlete-year-competition joint fixed effects. The other two columns are estimated using first differences. In column (2) we use as instruments once-lagged predetermined regressors, whereas in column (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 column 1. Windmeijer (2005) corrected robust standard errors based on a two-step estimation procedure are reported in parenthesis in columns 2 and 3: *significant at 10%; **significant at 5%; ***significant at 1%.

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

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Estimation method | OLS | OLS | OLS | OLS | OLS |
| Dependent variable | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ |
| **Rank 2** | -0.038* | -0.040** | -0.033 | 0.021 | 0.039 |
| | (0.020) | (0.020) | (0.022) | (0.025) | (0.025) |
| **Rank 3** | -0.056*** | -0.058*** | -0.042* | 0.041 | 0.070** |
| | (0.022) | (0.022) | (0.024) | (0.026) | (0.028) |
| **Rank 4** | -0.060*** | -0.062*** | -0.031 | 0.068** | 0.131*** |
| | (0.022) | (0.022) | (0.025) | (0.027) | (0.028) |
| **Rank 5** | -0.079*** | -0.081*** | -0.045* | 0.075*** | 0.149*** |
| | (0.023) | (0.023) | (0.026) | (0.027) | (0.030) |
| **Rank 6** | -0.051** | -0.054** | -0.006 | 0.117*** | 0.202*** |
| | (0.024) | (0.024) | (0.027) | (0.029) | (0.030) |
| **Rank 7** | -0.037 | -0.041* | 0.018 | 0.148*** | 0.240*** |
| | (0.024) | (0.024) | (0.027) | (0.028) | (0.030) |
| **Rank 8** | -0.012 | -0.015 | 0.040 | 0.173*** | 0.269*** |
| | (0.024) | (0.024) | (0.027) | (0.029) | (0.031) |
| **Rank 9** | -0.001 | -0.005 | 0.061** | 0.207*** | 0.310*** |
| | (0.024) | (0.024) | (0.027) | (0.029) | (0.031) |
| **Rank 10** | 0.015 | 0.013 | 0.082*** | 0.230*** | 0.338*** |
| | (0.025) | (0.025) | (0.028) | (0.029) | (0.031) |
| **Announcement$_{itjs}$ * stage2** | -0.014*** | -0.014*** | -0.015*** | -0.021*** | -0.022*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| **Announcement$_{itjs}$ * stage3** | -0.013*** | -0.013*** | -0.014*** | -0.020*** | -0.021*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| **Announcement$_{itjs}$ * stage4** | -0.012*** | -0.012*** | -0.013*** | -0.018*** | -0.019*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| **Announcement$_{itjs}$ * stage5** | -0.012*** | -0.012*** | -0.013*** | -0.018*** | -0.019*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| **Announcement$_{itjs}$ * stage6** | -0.012*** | -0.012*** | -0.012*** | -0.017*** | -0.018*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| **Bodyweight$_{itj}$** | 0.009*** | 0.009*** | 0.010** | | |
| athlete's bodyweight in Kg | (0.003) | (0.003) | (0.004) | | |
| **Home$_{itj}$** | 0.073*** | 0.074*** | 0.103*** | | |
| competing in home country | (0.019) | (0.019) | (0.026) | | |
| **Number of Competitors$_{itj}$** | -0.004*** | -0.005*** | -0.007*** | | |
| competitors at each game | (0.001) | (0.001) | (0.001) | | |
| Observations | 34625 | 34625 | 34625 | 34625 | 34625 |
| Clusters | 3763 | 3763 | 3763 | 3763 | 3763 |
| Athlete FE | yes | yes | | | |
| Competition FE | yes | | | yes | |
| Year FE | yes | | yes | | |
| Competition-Year FE | | yes | | | |
| Athlete-Competition FE | | | yes | | |
| Athlete-Year FE | | | | yes | |
| Athlete-Year-Competition FE | | | | | yes |

Notes: 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. The first three columns also include country of origin binary indicators. The coefficients for ranks 11-20 are omitted; the full table is reported in Appendix A (Table A3). Standard errors clustered at the athlete level are reported in parentheses below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

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

| | (1) | (2) | (3) |
|---|---|---|---|
| Estimation method | FE | FD (IV) | FD (GMM) |
| Dependent variable | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ |
| **Announcement$_{itjs}$** | -0.012*** | -0.009*** | -0.011*** |
| | (0.001) | (0.001) | (0.001) |
| **Rank$_{itj(s-1)}$** | 0.053*** | 0.024*** | 0.028*** |
| | (0.002) | (0.004) | (0.004) |
| **Rank$^2_{itj(s-1)}$ (x $10^{-3}$)** | -0.461*** | -0.343*** | -0.381*** |
| | (0.058) | (0.106) | (0.104) |
| Observations | 27700 | 27700 | 27700 |
| Clusters | 3763 | 3763 | 3763 |

Notes: The dependent variable is the announcement by athlete *i* , in year *t* , in competition *j* , at stage *s* of the game. The first column is estimated using athlete-year-competition joint fixed effects. The other two columns are estimated using first differences. In column 2 we use as instruments once-lagged predetermined regressors, whereas in column 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 column 1. Windmeijer (2005) corrected robust standard errors based on a two-step estimation procedure are reported in parenthesis in columns 2 and 3: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 6 - THE IMPACT OF RANK ON THE PROBABILITY OF A SUCCESSFUL LIFT - ROBUSTNESS

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Estimation method | FD (GMM) | FD (GMM) | FD (GMM) | FD (GMM) | FD (GMM) |
| Dependent variable | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ | Pr(success) $_{itjs}$ |
| **Announcement$_{itjs}$** | -0.011*** | -0.009*** | -0.011*** | 0.000 | -0.012*** |
| | (0.001) | (0.001) | (0.001) | (0.002) | (0.001) |
| **Rank$_{itj(s-1)}$** | 0.028*** | 0.024*** | 0.023*** | 0.036*** | 0.041*** |
| | (0.004) | (0.004) | (0.007) | (0.007) | (0.005) |
| **Rank$^2_{itj(s-1)}$ (x $10^{-3}$)** | -0.381*** | -0.299*** | -0.368*** | -0.475** | -0.616*** |
| | (0.104) | (0.103) | (0.108) | (0.187) | (0.128) |
| **Close Competition** | | -0.143*** | | | |
| dummy=1 if competitors' density within 10Kg radius is high | | (0.021) | | | |
| **Potential Gains** | | | 0.008 | | |
| potential change in rank if successful | | | (0.006) | | |
| **Tiredness** | | | | -0.001*** | |
| cumulative kilos attempted | | | | (0.000) | |
| Observations | 27700 | 27700 | 27700 | 27700 | 20775 |
| Clusters | 3763 | 3763 | 3763 | 3763 | 3763 |

Notes: The dependent variable is the announcement by athlete *i* , in year *t* , in competition *j* , at stage *s* of the game. All equations include stage of the competition binary indicators. Column 1 simply reproduces column 3 from Table 5 to ease comparisons. In column 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 parenthesis: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 7 - THE IMPACT OF RANK IN PRESTIGIOUS AND NON-PRESTIGIOUS COMPETITIONS

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | **All athletes** | | **Same athletes in both competitions** | |
| | Non-prestigious | Prestigious | Non-prestigious | Prestigious |
| **Rank 1** | 0.070* | | 0.016 | |
| | (0.040) | | (0.055) | |
| **Rank 2** | 0.116*** | 0.000 | 0.055 | -0.010 |
| | (0.039) | (0.032) | (0.060) | (0.066) |
| **Rank 3** | 0.160*** | 0.000 | 0.052 | -0.040 |
| | (0.039) | (0.034) | (0.059) | (0.063) |
| **Rank 4** | 0.163*** | 0.048 | 0.047 | -0.065 |
| | (0.039) | (0.036) | (0.063) | (0.065) |
| **Rank 5** | 0.165*** | 0.059* | 0.050 | -0.028 |
| | (0.040) | (0.036) | (0.066) | (0.062) |
| **Rank 6** | 0.220*** | 0.094*** | 0.104 | -0.070 |
| | (0.041) | (0.037) | (0.068) | (0.066) |
| **Rank 7** | 0.255*** | 0.122*** | 0.126* | -0.003 |
| | (0.041) | (0.037) | (0.070) | (0.067) |
| **Rank 8** | 0.283*** | 0.148*** | 0.100 | 0.039 |
| | (0.041) | (0.037) | (0.069) | (0.066) |
| **Rank 9** | 0.315*** | 0.183*** | 0.157** | 0.054 |
| | (0.042) | (0.037) | (0.069) | (0.070) |
| **Rank 10** | 0.350*** | 0.199*** | 0.177** | 0.093 |
| | (0.043) | (0.037) | (0.074) | (0.068) |
| **Rank 11** | 0.362*** | 0.230*** | 0.197** | 0.055 |
| | (0.043) | (0.037) | (0.076) | (0.069) |
| **Rank 12** | 0.378*** | 0.272*** | 0.153* | 0.150** |
| | (0.045) | (0.038) | (0.079) | (0.073) |
| **Rank 13** | 0.430*** | 0.281*** | 0.235*** | 0.116 |
| | (0.045) | (0.038) | (0.083) | (0.071) |
| **Rank 14** | 0.422*** | 0.300*** | 0.276*** | 0.088 |
| | (0.048) | (0.038) | (0.088) | (0.077) |
| **Rank 15** | 0.500*** | 0.327*** | 0.312*** | 0.149** |
| | (0.050) | (0.038) | (0.095) | (0.075) |
| **Rank 16** | 0.487*** | 0.369*** | 0.221** | 0.185** |
| | (0.051) | (0.039) | (0.091) | (0.084) |
| **Rank 17** | 0.520*** | 0.383*** | 0.349*** | 0.195** |
| | (0.057) | (0.041) | (0.094) | (0.081) |
| **Rank 18** | 0.516*** | 0.416*** | 0.147 | 0.237*** |
| | (0.063) | (0.040) | (0.154) | (0.077) |
| **Rank 19** | 0.566*** | 0.448*** | 0.167 | 0.216** |
| | (0.066) | (0.042) | (0.135) | (0.090) |
| **Rank 20** | 0.649*** | 0.501*** | 0.440*** | 0.226*** |
| | (0.052) | (0.036) | (0.090) | (0.065) |
| Observations | 34625 | | 7385 | |
| Clusters | 3763 | | 523 | |
| Athlete-Year FE | yes | | yes | |

Notes: 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, both for prestigious (P=1) and non-prestigious competitions (P=0), where $\text{Announcement}^*_s$ is the average announcement for stage s, and $\tau_s^P$ is the estimated stage-specific coefficient. The impact of rank one in prestigious competitions is normalized to zero. The estimated coefficients using athlete-year FE are reported in Appendix A (Table A4). The sample size in the last two columns is restricted to the athletes that participated in both types of games in the same year.

TABLE 8 - THE IMPACT OF INTERIM RANK ON PERFORMANCE IN DIVING

| | (1) | (2) | (3) |
|---|---|---|---|
| Estimation method | FE | FD (IV) | FD (GMM) |
| Dependent variable | Score $_{itjs}$ | Score $_{itjs}$ | Score $_{itjs}$ |
| **Degree of Difficulty$_{itjs}$** | 11.232*** | 9.960*** | 9.902*** |
| | (1.095) | (1.122) | (1.195) |
| **Rank$_{itj(s-1)}$** | 1.958*** | 0.569** | 0.693** |
| | (0.181) | (0.275) | (0.291) |
| Observations | 3029 | 3029 | 3029 |
| Clusters | 364 | 364 | 364 |

Notes: The dependent variable is the score achieved by athlete *i* , in year *t* , in competition *j* , at stage *s* of the game. The first column is estimated using athlete-year-competition joint fixed effects. The other two columns are estimated using first differences. In column (2) we use as instruments once-lagged predetermined regressors, whereas in column (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 column 1. Windmeijer (2005) corrected robust standard errors based on a two-step estimation procedure are reported in parenthesis in columns 2 and 3: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 9 - THE IMPACT OF INTERIM RANK ON PERFORMANCE IN DIVING - ROBUSTNESS

| | (1) | (2) | (3) |
|---|---|---|---|
| Estimation method | FD (GMM) | FD (GMM) | FD (GMM) |
| Dependent variable | Score $_{itjs}$ | Score $_{itjs}$ | Score $_{itjs}$ |
| **Degree of Difficulty$_{itjs}$** | 9.921*** | 13.773*** | 9.364*** |
| the degree of difficulty of the attempted dive | (1.193) | (0.951) | (1.252) |
| **Rank$_{itj(s-1)}$** | 0.654** | 2.547*** | 0.699** |
| | (0.294) | (0.215) | (0.291) |
| **Close Competition** | -1.281* | | |
| Dummy = 1 if competitors' density within 10 points radius is high | (0.659) | | |
| **Potential Gains** | | -3.651*** | |
| number of gained ranks if perfect score | | (0.134) | |
| **Tiredness** | | | -0.863** |
| cumulative degree of difficulty attempted | | | (0.354) |
| Observations | 3029 | 3029 | 3029 |
| Clusters | 364 | 364 | 364 |

Notes: The dependent variable is the score achieved by athlete *i* , in year *t* , in competition *j* , at stage *s* of the game. All equations include stage of the competition binary indicators. All available moment restrictions are used in the estimation. Windmeijer (2005) corrected robust standard errors based on a two-step estimation procedure are reported in parenthesis: *significant at 10%; **significant at 5%; ***significant at 1%.