6. Earnings and performance in women's skiing

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6.1 INTRODUCTION

Economic research on the performance of individual professional athletes has grown substantially over the last 20 years. The first reason for the growth is the substantial increase in the earnings of professional athletes. In 1968, the first prize for winning the US Open tennis tournament was \$14,000, or about \$91,200 in 2011 dollars. The winner, US Army Lt. Arthur Ashe, was an amateur and could not collect the check. Virginia Wade won the women's title and earned \$6,000, about \$39,000 in 2011 dollars. In 2011 Novak Djokovic and Samantha Stosur each collected \$1.8 million dollars for winning this tournament. The second reason for the increase in research on the performance of individual professional athletes is the seminal work on the effects of rank tournaments on labor supply and effort by Lazear and Rosen (1981). They show that rank-order tournaments, where only the order of finish affects earnings, coupled with a nonlinear payoff in the tournament, can produce the same level of profit as a compensation mechanism that pays all workers their marginal revenue products. The crucial advantage of the Lazear and Rosen framework is that the employer does not have to observe the marginal product of the worker.

Lazear and Rosen set out to explain observed compensation in corporations, envisioning the firm's managers as competitors in a tournament for the position of CEO, a position that typically pays much more than other corporate positions. However, the effort or output of individual employees in corporations is rarely observable. Analogously, competition in individual sports is typically a rank-order tournament with nonlinear payoffs. Many athletic tournaments, like professional golf, tennis, bowling, and foot races, are rank-order competitions with nonlinear payoffs. These provide an ideal setting for testing the predictions of the model developed by Lazear and Rosen.

Most tests of the Lazear and Rosen model that use data from professional sports confirm that the effort supplied by participants responds to the prize structure in a way consistent with the model. However, most of

these tests use data from men's individual professional sports, starting with Ehrenberg and Bognanno (1990a, 1990b), who analyzed outcomes in professional golf tournaments. Much of the subsequent work is summarized in Szymanski (2003).

Relatively little research has focused on outcomes in women's professional individual sports. Coate and Robbins (2001) analyzed the earnings and career length of men's and women's professional tennis players over the 1984–94 period. Maloney and McCormick (2000) investigated the outcome of foot races involving both men and women over the 1987–91 period. Lallemand et al. (2008) examined outcomes in Women's Tennis Association (WTA) Tour tennis matches over the 2002–04 period. Gilsdorf and Sukhatme (2008) studied the outcomes of matches on the WTA Tour in the 2004 season while Frick (2011) analyzed outcomes of male and female runners in professional distance running events over the 1973–2009 period. No previous research has focused on outcomes in women's professional alpine skiing.

Recent research on gender differences in preferences heightens interest in understanding differences in the performance of male and female professional athletes. Croson and Gneezy (2009) recently surveyed developments in the literature on gender differences in preferences. Economists have observed systematic gender differences in economic decisions in consumption, investment, and labor markets. An emerging literature attributes these differences to underlying differences in the preferences of men and women. In particular, recent research suggests that men and women have significant differences in risk preferences, social preferences and, most important for this chapter, preferences for competition. Croson and Gneezy conclude from recent research that 'women are more averse to competition than are men' (p. 1), that 'women are more reluctant than men to engage in competitive interactions like tournaments' (p. 17), and that 'men's performance, relative to women's, is improved under competition' (p. 17). All of the evidence discussed by Croson and Gneezy comes from experimental settings; none is based on evidence from the field. The emerging evidence about gender differences in preferences increases the need for research on how women respond to competitive forces, including the performance of female professional athletes.

In this chapter, we analyze the performance of female professional Downhill skiers in the Fédération Internationale de Ski (FIS, or International Ski Federation) Alpine Ski World Cup. To test the predictions of tournament theory, we use data from World Cup skiing competitions, which is the top international circuit of alpine skiing competitions. The individual races that make up the FIS Alpine Ski World Cup are rank-order tournaments that have a relatively large, nonlinear payoff

structure. The participants in these events can supply a variable amount of effort in the contests by choosing to ski faster or slower. Tournament theory predicts that the effort supplied by participants in a tournament will respond to the size and spread of the prize distribution.

Like Ehrenberg and Bognanno (1990a and 1990b), we find that professional athletes respond to a tournament prize structure in a way consistent with the Lazear and Rosen model. In particular, we find that the greater the spread of the prize distribution, the more effort female skiers exert. Differences in gender preferences may also play an important role in this setting, which could lead female skiers not to respond strongly to tournament incentives; we have weak evidence that this may take place.

Section 6.2 explains the history and structure of the FIS Alpine Ski World Cup competition. Section 6.3 places this chapter in the context of the broader literature applying rank-order tournaments to professional sports. Section 6.4 describes the data used in the analysis, and Section 6.5 presents and estimates the empirical model. Section 6.6 concludes.

6.2 THE FIS ALPINE SKI WORLD CUP

The FIS was founded in 1924 in Chamonix France. Its creation was part of 'International Winter Sports Week', an event that was later declared to be the first Winter Olympic Games. Today, the FIS sets rules for and oversees world championships in the Olympic ski disciplines of cross-country, ski jumping, Nordic combined, alpine, freestyle, and snowboarding, as well as in a variety of non-Olympic events, such as speed skiing, grass skiing, and telemark (FIS, 2012).

The FIS Alpine Ski World Cup (hereafter 'World Cup') began competition in 1967. Today, it is the world's premier international alpine ski competition. In its first season, the World Cup staged 18 races for men and women in three alpine skiing events: Slalom, Giant Slalom, and Downhill. The men's world champion in the first two seasons was Jean-Claude Killy of France, who won 12 of the 18 races in the inaugural season; the women's world champion in the first two seasons was Canadian Nance Greene. World Cup races are part of a tour that travels to famous ski resorts in the European Alps, Scandinavia, North America, and Asia over a season that runs from late October until mid-March.

The World Cup currently consists of five alpine skiing events: Slalom, Giant Slalom, Super-G, Downhill, and Super-combined, a composite event that consists of one short Downhill run and one Slalom run. Alpine skiing events take place on courses that are defined by gates formed by pairs of poles that alternate in color. The tips of both skis and the skiers'

feet must pass between the poles that make up each gate, or the skier is disqualified from the race. Slalom and Giant Slalom races consist of two runs each. The skier with the lowest combined times for the two runs is the winner of the race. The Super-G and Downhill have only one run each.

The events are distinguished by the number of gates that make up each course and the vertical drop of the course. In general, events with larger vertical drops and fewer gates have faster speeds. FIS has detailed rules for the design of the course for each alpine event (see FIS 2012 for details).

Slalom and Giant Slalom are 'technical' events with many gates placed close together, requiring the skier to make many rapid, tight turns. The many turns, combined with a relatively small vertical drop, result in slower speeds. A Slalom course has 55–75 gates for men, 40–60 gates for women, and it has no vertical drop requirement. Slalom gates have a width of 4–6 meters. A Slalom race consists of two runs on two different courses. A Giant Slalom course has a vertical drop of 250–400 meters, and it has 56–70 gates for men and 46–58 gates for women. Giant Slalom gates have a width of 4–8 meters and must be at least 10 meters apart. Speeds are faster on the Giant Slalom than on the Slalom because the vertical drop is greater and the gates require less turning.

Super-G and Downhill are considered 'speed' events. A Super-G course has a vertical drop of between 400 and 650 meters for men and between 400 and 600 meters for women, with gates that are 6–8 meters wide. A Downhill course has a vertical drop of between 800 and 1,100 meters for men and between 450 meters and 800 meters for women and only a few gates. As a result, the speeds on the Super-G and especially the Downhill are far greater than on the Slalom or Giant Slalom, with speeds on the Downhill sometimes exceeding 90 miles per hour.

While the design of the course strongly influences the skiers' speeds, FIS rules clearly assume that individual athletes have some control over how fast they go. For example, the FIS rules for the Downhill state: 'It must be possible to ski the Downhill course from the start to the finish with different speeds. The athlete adapts speed and performance to his ski technical skills and to his individual self-responsible judgment.' A skier's speed in these races is, to some degree, under the control of each participant, and the courses are designed in a way that allows participants to alter their speed, depending on their skills and preferences.

An FIS World Cup race consists of five events held at the same ski resort over a period of 2–3 days. Each event has a cash reward, paid in euros or Swiss francs to the top finishers in the event. The size and spread of these awards vary across events and across races. Since the 1991–92 season, the top 30 competitors have also earned points based on the order of finish in each event. The winner gets 100 points, the second-place finisher gets

Figure 6.1 FIS World Cup scoring system

80 points, and the third-place finisher 60 points. Nonlinearities set in with the fourth-place finisher, who gets 55 points. Points then fall by four points for the 5th through 7th place, by three points for 8th through 12th place, two points for 13th through 21st place, and one point for 22nd through 30th place. As Figure 6.1 shows, the prize structure is piecewise linear with the penalty for a lower finish decreasing as one moves down the leader board. Total points are added for all events in the racing season, and the man and woman with the highest point total in each event wins the World Cup Championship for that event. In 2011, the first-place finisher in the season-long World Cup competition won 40,000 Swiss francs (CHF), the second-place finisher 25,000 CHF, the third-place finisher 15,000 CHF, the fourth-place finisher 10,000 CHF, the fifth-place finisher 6,000 CHF, and the sixth-place finisher 4,000 CHF. Like point totals, monetary prize differentials steadily decrease as a skier's placement worsens.

6.3 TOURNAMENT THEORY AND PROFESSIONAL SPORTS

Tournament theory dates back to Lazear and Rosen's (1981) seminal article. Initially applied to corporate labor markets, it has since been

applied to a variety of sports. (See Frick, 2003, for a good survey of this literature.) Tournament theory posits that participants possess endowments of ability and choose an optimal amount of effort, given the ability and talent of their competitors and the prize structure of the tournament, which is known in advance. The contest is rank-ordered, so prizes are based only on relative performance, which depends on both the optimal effort of the participants as well as a random component attributed to luck and other stochastic factors outside the control of contestants. Later work (such as O’Keeffe et al., 1984, and Brown, 2011) has acknowledged that competitors might have different levels of talent and ability. As a result, the optimal choice of effort depends on the distribution of talent and ability across competitors, the expectation of effort made by other participants, and the prize structure.

Three testable predictions emerge from tournament theory. The optimal degree of effort depends

1. positively on the size and spread of the prize distribution;
2. negatively on the marginal cost of effort; and
3. positively on the degree to which an increase in individual’s effort affects the probability of winning the contest.

Most research applying tournament theory to sports focuses on tests of prediction (1) because we can observe the contest features required to test the hypothesis. Since the marginal cost of effort cannot be easily observed in many settings, prediction (2) is difficult to test. Prediction (3) is also hard to test, as tournament theory provides no guidance as to the form of the relationship between effort and the probability of winning. Thus, we test prediction (1).

Most empirical tests of prediction (1) focus on the relationship between the size and structure of the prize pool and the effort made by contestants. Sporting events represent a natural setting for testing the predictions of tournament theory because both the contestants’ effort and the size and structure of the prize pool are easily observed. In general, researchers identify an observable variable as a proxy for effort that varies across participants, and they explain observed variation in that effort proxy with variables reflecting the size and spread of the prize pool, event-specific characteristics, and participant-specific characteristics. Studies using data from golf and bowling typically use measures of previous performance to control for players’ underlying ability and game or round scores as proxies for effort. Studies using foot races or car races use race time, and studies using data from tennis typically estimate probit models of the probability that a player wins a given match.

Maloney and McCormick (2000) performed one of the first tests of tournament theory that used data on female athletes. They analyzed the outcomes of 1,426 open foot races of various distances held over the 1987–91 period in the southeast US. These races were relatively low stakes events; the average prize was just \$300 to \$400, and the maximum payoff was \$4,000 for women and \$8,000 for men. They pooled races across different distances from one mile to marathons (26 miles), introducing a great deal of heterogeneity in the competitors. The dependent variable was average time per mile run in the race. The estimated parameter on both prize spread and average prize was negative for all models estimated, suggesting that both male and female runners respond to the prize structure consistent with the predictions of tournament theory. The bigger the prize and the larger the spread in the prize distribution, the more effort supplied by contestants and the faster they ran, given their abilities.

Coate and Robbins (2001) analyzed data from professional tennis, but they did not analyze effort. Instead, they examined factors that explain why players drop out of the top 250 places in the world tennis rankings, which effectively means that they retired from professional tennis. They found no evidence that women retire earlier than men, suggesting that they provide equal effort in professional tennis contests.

Lallemant et al. (2008) analyzed outcomes in women's professional tennis. Their effort proxy was the number of games won by a player in a match in tennis tournaments over the 2002–06 period. They calculated the difference in prize money that would be earned if the player won the match compared to the amount that she would have earned if she had lost. The estimated parameter on this prize differential was positive and significant in all models estimated, suggesting that the bigger the spread in prizes, the more effort the player made in a tennis match. The dependent variable in the analysis is limited by the number of sets played, which sets an upper bound on the participant's ability to increase effort.

Gilsdorf and Sukhatme (2008) examined match outcomes in women's professional tennis in the 2004 season. Their effort proxy was a dummy variable equal to one if the higher-ranked player won the match. Their prize spread variable was the difference between the top prize in each tournament and the prize the player would win if she lost the current match. The estimated parameter on this prize spread variable was positive and significant in all models estimated. This result implies that the bigger the spread in prizes in a match, the more likely the higher-ranked player was to win that match, which, in turn, suggests that the player provided greater effort.

Frick (2011) analyzed outcomes in 5k, 10k, half marathons, and marathons over a 40-year period. This paper explicitly compared the performance of female to male runners. The effort variable reflected the percentage

difference in women's finishing times relative to men's in the same race for runners with the same world ranking. Explanatory variables included the rank of the participants in world rankings and their rank squared. Frick found that the difference in the relative performance of men and women of the same rank increases as their rank improves. He concluded that highly ranked women did not have to put in as much effort as highly ranked men to win their races. He also found that the performance gap narrowed considerably over time, suggesting that the gender gap has been closing in distance running. Clearly, this narrowing gap in performance cannot be attributed to changing preferences.

All of these papers found that female professional athletes respond to tournament incentives in a way that is consistent with the predictions of Lazear and Rosen's (1981) model. The bigger the prize and the larger the spread of the prize distribution, the more effort female professional athletes supply in these sports. Croson and Gneezy (2009) point out that gender differences in preferences for competition may be manifested in decisions to participate and not necessarily in effort supplied in competitions. If the most competitive females self-select into the competitions analyzed, then these studies might yield biased estimates because they fail to take account of self-selection. Thus, tests of the predictions of tournament theory in other settings involving female athletes are needed.

6.4 DATA

We obtained data on the outcomes of all FIS World Cup women's events for the 2001–02 season through the 2010–11 season from the FIS. We analyze outcomes for two events: the Downhill and the Giant Slalom. Recall that the Downhill is a 'speed' event, that involves few turns, and the Giant Slalom is a 'technical' event that involves many turns, so speeds are much faster for the Downhill than the Giant Slalom. The number of events held each season varies because some events are canceled due to weather conditions, such as ice, snow, and high temperature.

We have data on course characteristics, prize structure, and race outcomes. Course characteristics are captured by the vertical drop of the course and the number of gates. The prize structure of each race is defined by the amount awarded to each finisher and the total amount of prize money awarded in the event. Regardless of the event's location, prizes are paid in either euros or Swiss francs. To compare the prize structures in the events, we convert all prizes that are awarded in Swiss francs to euros at the current exchange rate. We also deflate the prize money to constant 2010 dollars using the harmonized index of consumer prices, which serves

Table 6.1 Summary statistics

Variable	Downhill				Giant Slalom			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
No. of entrants	54.00	9.71	12.00	71.00	61.62	15.64	26.00	81.00
Race time, seconds	97.47	11.80	69.12	126.41	142.64	13.92	96.96	214.90
Vertical drop, meters	711.08	76.27	451.00	800.00	364.17	32.11	270.00	416.00
No. of gates	37.26	5.21	23.00	50.00	47.00	4.99	31.00	59.00
Total prize*	89,335	18,457	49,991	112,360	87,129	18,057	49,311	112,360
No. of events	63				65			

Note: *Average total prize is calculated in euros.

the same basic role for the eurozone that the consumer price index (CPI) plays for the United States. Race outcomes are the total time each skier accumulated for each event, the total number of skiers who entered each event, and the total number of skiers who finished each event.

Table 6.1 shows summary statistics for the Downhill and Giant Slalom. There were an average of 54 entrants in each of the 63 Downhill races, and an average of 61 entrants in each of the 65 Giant Slalom races. Table 6A.1 in Appendix 6A contains a list of the events. Race time is our measure of effort. Recall that the Downhill, consisting of a single run down the mountain, is a long race with large vertical drops, few turns, and high speeds. In contrast, the Giant Slalom, consisting of two runs, is a shorter race with a smaller vertical drop and many turns. In addition to having more turns, the turns in the Giant Slalom are sharper because the gates are narrower and much closer together than in the Downhill. As a result, the gates in the Giant Slalom force the skier to move across the mountain much more than in the Downhill, causing the skier to move more slowly down the course.

The effort variable (that is, race time) has a relatively large standard deviation in both events. In part, this could reflect variation in the vertical drop of the races because the vertical drop determines both the maximum attainable speed and the danger of crashing during the race. The permissible range of vertical drops for each event is set by the FIS, but race organizers have some discretion. However, the standard deviation in vertical drop and the resulting coefficient of variation is much smaller for the vertical drop than it is for race time. This, in turn, suggests that the contestants, through differences in ability or effort, might have significant control over their times in the events.

Table 6.2 Prize distribution

Place	Event: Downhill			Event: Giant Slalom		
	Prize (€)	Difference (€)	% Difference	Prize (€)	Difference (€)	% Difference
1	51,825	16,970	48.69	60,613	24,674	68.66
2	34,855	11,141	46.98	35,939	13,539	60.44
3	23,714	8,085	51.73	22,400	7,250	47.85
4	15,629	4,521	40.70	15,150	5,238	52.85
5	11,108	2,550	29.80	9,912	2,886	41.08
6	8,558	1,881	28.17	7,026	1,923	37.68
7	6,677	1,153	20.87	5,103	1,142	28.83
8	5,524	1,081	24.33	3,961	1,068	36.92
9	4,443	1,217	37.72	2,893	953	49.12
10	3,226			1,940		

The key economic variable is the spread of the prize distribution in each event. The prizes awarded vary across events, race venues, and seasons; they appear in Table 6.2 in euros. Note that we converted Swiss francs to euros at current exchange rates for the empirical analysis. Even though most events have prizes paid in Swiss francs, we converted them to euros because of the availability of a price index for the eurozone over the sample period. For each event, the first column shows the average prize award for each of the first 10 places, the second column shows the absolute difference between the prize for each place, and the third column shows the percentage difference for the events with prizes awarded in euros.

The prize distribution is nonlinear, as the decrease in percentage terms is larger at the top of the distribution than at the bottom. The prize structure thus resembles that offered by such other sports, such as golf and bowling. All events awarded prizes to the first 10 finishers, but some races awarded prizes to lower finishers as well. We show the first 10 prizes here to save space, but when calculating measures of the prize distribution spread we use all of the prizes awarded.

The prize distribution in some of these events is not as nonlinear as found in other individual sports, especially for the Downhill events with prizes paid in euros. In sports like golf, tennis, and running, dropping from first to second place almost always brings a decline in prize money of more than 50 percent. Tournament theory is silent on the desired convexity of the prize gradient; it predicts only that a nonlinear prize distribution is needed to induce maximum effort from contest participants.

The prize gradient for skiing more closely resembles that for NASCAR

(National Association for Stock car Auto Racing), whose gradient is even flatter. Von Allmen (2001) explains that NASCAR penalizes lower finishers relatively little because it fears the negative externalities associated with trying 'too hard'. In particular, it fears that overly aggressive driving could result in crashes that endanger the driver and other drivers. FIS limits the prize structure for a similar reason. Skiers who approach the course very aggressively face a significant risk of crashing or missing a gate and not completing the race. The risk of crashing or missing a gate clearly increases with effort supplied by skiers. While many crashes and missed gates do not endanger other skiers, too many disqualifications might undermine a race's credibility. Race organizers may not set highly nonlinear prize distributions to reduce the number of participants who crash during the events.

6.5 EMPIRICAL ANALYSIS

We follow the standard procedure used in the literature for testing the predictions of tournament theory. We estimate a reduced-form empirical model of the determination of the speed of each competitor in the event, a proxy for effort supplied by the contestants. We explain observed variation in effort with a vector of characteristics of the specific contests and with a variable reflecting the spread of the prize distribution. The empirical model estimated is:

$$e_{ijkt} = \alpha_1 \mathbf{A}_t + \alpha_2 \mathbf{B}_k + \beta_1 \mathbf{CC}_{jk} + \beta_2 PS_{jkt} + \mu_{ijkt}, \quad (6.1)$$

where e_{ijkt} is the effort made in each event, captured by the total seconds raced by competitor i in event j at race location k in season t . The empirical model does not control for individual heterogeneity in ability using random or fixed effects; instead, we use OLS on a pooled sample of race participants.

$\mathbf{A}_t$ is a vector of indicator variables for each World Cup season in the sample. This vector controls for unobservable heterogeneity in seasons due to variation in equipment requirements and other factors that are constant within one racing season but change systematically across race seasons.

$\mathbf{B}_k$ is a vector of indicator variables for each venue at which the World Cup races take place. This vector controls for unobservable heterogeneity in the venues that might result from idiosyncratic conditions at each venue, such as topography.

$\mathbf{CC}_{jk}$ is a vector of variables capturing event-specific characteristics. This vector includes the vertical drop of the course, the number of gates on the course, and the number of entrants in the event. As noted earlier, we

expect times to be inversely related to the number of gates. The impact of the vertical drop is theoretically ambiguous. The course effect itself should reduce times, as a steeper course over a relatively fixed distance will cause skiers to go downhill more quickly. However, this might be offset by the behavior of skiers, who must slow down to maintain control and avoid crashing or missing gates.

PS_{jkt} is our measure of the spread of the prize distribution in event j at venue k in season t . This is the key explanatory variable because it captures the incentive effects generated by the prize distribution in each event at each venue. We use two alternative measures of the spread of the prize distribution: the standard deviation of the prize distribution and the interquartile range of the prize distribution. The interquartile range is the difference between the prize value at the 75th percentile of the prize distribution and the value at the 25th percentile. In one model, we replace the spread of the prize distribution with the total prize money awarded, as tournament theory also predicts that the total size of the prize pool can affect effort supplied. The above models are consistent with the standard methodology used in the field.¹ While prize spread affects only effort, total purse can affect both entry decisions and effort decisions, which could reduce effort. Because of these offsetting effects, most empirical analysis estimates separate models for purse and spread. Tournament theory predicts that the greater the spread in the prize distribution, and the larger the prize pool, the more effort contestants supply. This implies that the sign of the parameter estimate on the prize distribution spread and prize pool variables should be negative. More effort supplied means faster times in each event.

The random error term μ_{ijkt} is unobservable and captures all other factors that affect race outcomes and effort supplied by contestants, which we assume to be randomly distributed across skiers. We also assume that this error term is mean zero and identically and independently distributed. We allow the variance to vary across both venues and events.

Parameters α_1 , α_2 , β_1 and β_2 are unobservable and must be estimated. We use STATA to perform OLS estimates of these parameters and estimate separate equations for the Downhill and Giant Slalom races. We correct the standard errors for clustering at the event level, since the measure of the spread of the prize distribution and the course characteristics vary only over events, and not over contestants. We also correct for heteroskedasticity in the equation error term using the standard White–Huber ‘sandwich’ correction.

Table 6.3 lists the parameter estimates and regression diagnostics for the two ski events we analyze. The three columns on the left are for the Giant Slalom (GS); the three columns on the right are for the Downhill (DH). Standard errors are in parentheses. Again, all empirical models control for

Table 6.3 OLS regression results

Variable	GS1	GS2	GS3	DH1	DH2	DH3
Std dev.	-0.228** (0.102)	—	—	-0.202*** (0.031)	—	—
IQR	—	0.044 (0.061)	—	—	-0.181*** (0.026)	—
Total prize	—	—	-0.011 (0.010)	—	—	-0.31*** (0.004)
No. of entrants	0.014 (0.014)	0.012 (0.014)	0.013 (0.014)	0.088*** (0.009)	0.088*** (0.009)	0.091*** (0.009)
Vertical drop	0.206*** (0.015)	0.231*** (0.015)	0.211*** (0.015)	0.139*** (0.001)	0.139*** (0.001)	0.139*** (0.001)
No. of gates	1.390*** (0.106)	1.341*** (0.103)	1.354*** (0.103)	0.447*** (0.022)	0.449*** (0.022)	0.463*** (0.023)
R ²	0.94	0.95	0.95	0.98	0.98	0.98
Contestants	1,789	1,789	1,789	2,997	2,997	2,997
Races	65	65	65	63	63	63

Notes:

Standard errors in parentheses.

** Significant at 5% level; *** Significant at 1% level.

All models contain season- and venue-specific effects. Standard errors corrected for clustering at the event level.

a season-specific effect and a venue-specific effect to capture unobservable heterogeneity. These controls help explain the high R^2 s in Table 6.3 but do not appear there.

The parameter estimates on the number of entrants are positive and significant in all Downhill and Giant Slalom specifications. Other things equal, the more skiers in a field, the slower the times. This probably reflects the fact that race course conditions deteriorate somewhat with each run. Each participant that skis the course leaves ruts and other imperfections in the course, especially along the optimal path. As expected, the parameter estimates for the number of gates is positive and significant. Turns slow down the skier, and these results indicate that the more turns the skier must make, the slower the speed. The effect of an additional gate is smaller on the Downhill than on the Giant Slalom because turning is less important in the Downhill.

The estimated parameter on the vertical drop variable is also positive and significant in all model specifications. This suggests that the skiers' behavior more than offsets the gravitational forces inherent in a larger vertical drop. As explained above, a course with a larger vertical drop will naturally lead to greater speeds, but it will also cause skiers to be more

cautious, leading to slower speeds. The positive sign on this parameter indicates that the crash avoidance motive dominates in these races.

The parameter estimates of greatest interest are those on the measures of the spread of the prize distribution in each event. Recall that we use two measures of this spread, the standard deviation of the prize distribution and the interquartile range. In three of the four model specifications, the parameter estimates are negative and significantly different from zero at conventional levels. This indicates that the greater the spread of the prize distribution, the more effort supplied by women in World Cup competitions. Female professional skiers respond to tournament incentives. The sole exception is the Giant Slalom when the spread of the prize distribution is captured by the interquartile range. Here, the estimated parameter on the spread variable is not statistically different from zero. This result may suggest that female skiers do not always respond to tournament incentives, or it could simply reflect differences in the two races; the Giant Slalom might not provide enough variability in times for the effect of the prize spread to be easily detected. Alternatively, this lack of a relationship suggests that some racers, in some events, do not ski faster when there is a larger spread of the prize distribution. This could reflect aversion to competitiveness, as discussed by Croson and Gneezy (2009).

The parameter estimate on the total prize variable is negative, but it is statistically significant only for the Downhill. In the Downhill, the more money awarded in a race, the faster the competitors ski, other things equal. In addition to – or even instead of – incentive effects, the lower times in races could reflect entry effects. In their study of road racing, Lynch and Zax (2000) and Frick (2003) find that better runners enter competitions that offer larger prizes. That could happen here as well. Higher prize pools could induce more high-quality skiers to enter a race, lowering the average time in the race. Moreover, the stronger incentive effects that we find for the Downhill might actually show that the entry effect is stronger for the Downhill. Unfortunately, we cannot address endogenous entry by professional female skiers since we lack an instrument that can explain entry decisions. As a result, identifying whether our results stem from incentive or entry effects is beyond the scope of this chapter.

6.6 CONCLUSIONS

A large, growing body of literature that tests the predictions of tournament theory in sports-related settings has emerged over the past two decades. The main question in these empirical investigations asks whether the relative performance of contestants will improve if a larger spread in

prizes is offered in a contest. The results of these studies are mixed, with some supporting tournament theory and others contradicting it.

We build on this literature by estimating the incentive effects of prize structure on alpine skiing. We use a unique dataset from FIS World Cup women's professional events that includes details on race conditions and race outcomes across 10 racing seasons (2001–11). Our analysis focuses on two events, the Downhill and the Giant Slalom, which separately reflect the 'speed' and 'technical' features in women's professional skiing races. Generally, our results show that the two measures of the spread of the prize distribution, the standard deviation and interquartile range, are significantly and negatively associated with racing time. We interpret this as demonstrating that the greater the prize spread, the greater the effort by female skiers. This new empirical evidence provides further support for the predictions of tournament theory.

It is possible that the chance of a greater prize might simply attract better skiers. Maloney and McCormick's (2000) finding that the quality of the field in road races varies with the size of the purse might apply to ski events as well. The better times might therefore reflect self-selection rather than changes in effort. One cannot firmly identify incentive effects until one has fully accounted for such entry effects. Developing an accurate measure of skier quality is also important because it would make unobserved heterogeneity, a potential problem for OLS estimation, less of a factor.

However, female skiers may not always respond to tournament incentives. The results for the Giant Slalom show that the estimated parameter value of the spread of the prize distribution represented by interquartile range does not differ significantly from zero. This result can be connected to the argument by Croson and Gneezy (2009) that women are reluctant to engage in competitive activities. This natural tendency in preferences could explain the ambiguity in our results. Alternatively, the Giant Slalom may not be a race in which competitors can easily increase effort, due to the many turns and gates in this race.

In addition to accounting for self-selection, this chapter suggests three future directions for research. First, one can test whether the findings for Downhill and Giant Slalom extend to the Slalom and Super-G as well as nordic races. Second, as noted above, race order could affect times. Ideally, one would include each racer's starting position for each race. Finally, this chapter is one of the few settings in which research on women has gone beyond the research on men. Estimation of incentive effects for male skiers would allow for an analysis of gender differences in preferences among professional skiers, since men and women compete in the FIS World Cup.

NOTE

1. Lynch and Zax (2000), Gilsdorf and Sukhatme (2008), Lallemand et al. (2008), and Frick and Humphreys (2011) take a similar approach.

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APPENDIX 6A

Table 6A.1 FIS races in the sample

Downhill	Giant Slalom
Altenmarkt-Zauchensee (Austria)	Adelboden (Switzerland)
Åre (Sweden)	Alta Badia (Italy)
Aspen (United States)	Altenmarkt-Zauchensee (Austria)
Bad Kleinkirchheim (Austria)	Arber-Zwiesel (Germany)
Bansko (Bulgaria)	Åre (Sweden)
Bormio (Italy)	Aspen (United States)
Chamonix (France)	Bad Kleinkirchheim (Austria)
Cortina d'Ampezzo (Italy)	Berchstegaden (Germany)
Crans-Montana (Switzerland)	Bormio (Italy)
Garmisch-Partenkirchen (Germany)	Copper Mountain (United States)
Groden (Italy)	Cortina d'Ampezzo (Italy)
Haus im Ennstal (Austria)	Flachau (Austria)
Innsbruck Path (Austria)	Garmisch-Partenkirchen (Germany)
Kitzbühel (Austria)	Hafjell (Norway)
Lake Louise (Canada)	Hinterstoder (Austria)
Lenzerheide (Switzerland)	La Molina (Spain)
Lillehammer (Norway)	La Villa-Alta Badia (Italy)
Saalbach-Hinterglemm (Austria)	Lienz (Austria)
San Sicario (Italy)	Lenzerheide (Switzerland)
Santa Caterina (Italy)	Lillehammer (Norway)
Sestriere (Italy)	Maribor (Slovenia)
St. Anton (Austria)	Ofterschwang (Germany)
St. Moritz (Switzerland)	Panorama BC (Canada)
Tarvisio (Italy)	Park City (United States)
Val d'Isère (France)	Kranjska Gora (Slovenia)
Vail/Beaver Creek (United States)	Santa Caterina (Italy)
Val d'Isère (France)	Schladming (Austria)
Val Gardena-Groeden (Italy)	Sestriere (Italy)
Veysonnaz (Switzerland)	Sierra Nevada (Spain)
Kvitfjell (Norway)	Sölden (Austria)
Wengen (Switzerland)	Špindlerův Mlýn (Czech Republic)
Whistler, BC (Canada)	St. Moritz (Switzerland)
Zauchensee (Austria)	Val d'Isère (France)
	Vail/Geaver Creek (United States)
	Whistler/Vancouver (Canada)
	Yongpyong (Korea)
	Zwiesel (Germany)