14. Gender differences in competitiveness: empirical evidence from 100m races

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14.1 INTRODUCTION

In recent years a broad consensus has emerged among social scientists about the existence of a considerable gender gap in competitiveness. We define ‘competitiveness’ as the willingness and ability to perform in a setting in which the payoff is explicitly based on the rank order of one’s performance. The reasons for the emergence and persistence of the gap remain highly contested. Researchers in different social sciences have proposed four explanations for the observed differences in behavior. To some degree these theories complement one another, and to some degree they compete with one another.

First, evolutionary psychologists posit that gender differences in competitiveness reflect predispositions that evolved because of men’s longer and more intense training and greater competitive motivation (for example, Deaner 2006a, 2006b, 2011). Second, medical experts and sports scientists claim that the observed pattern has its roots in physical differences between men and women, such as hormonally regulated variations in body fat and the cardiovascular system, a lower oxygen uptake capacity, greater susceptibility to injuries, and a weaker response to training efforts by women (see, *inter alia*, Cheuvront et al., 2005). Third, sociologists assert that gender differences in competitiveness result from socio-cultural conditions fostering differences in socialization of boys and girls (for example, Henslin, 1999). Finally, economists argue that behavioral differences of humans are largely motivated by differences in opportunities and incentive structures (for example, Becker, 1993).

In this chapter, we use cross-sectional and longitudinal data from 100-meter races (ranging from world-class competitions, such as the finals of the Olympic Games and the International Amateur Athletic Federation (IAAF) World Championships, to national and regional races) to empirically discriminate among these four approaches. By analyzing the performance of male and female sprinters at both the top level of competition and at less elite, albeit highly select, levels, we shed light on

the controversial question of whether men and women perform differently under competitive pressure.

Section 14.2 provides a selective review of the recent experimental and non-experimental literature. Section 14.3 describes the data and methodology and offers some descriptive statistics. Section 14.4 presents the econometric evidence, and Section 14.5 concludes with a brief summary and some implications for further research.

14.2 PREVIOUS EMPIRICAL RESEARCH

Although the literature on gender differences in competitiveness has recently grown rapidly, there is as yet no consensus concerning the reasons for its emergence and persistence. Moreover, the more fundamental question of whether the observed gender differences are due to genetic differences or behavioral characteristics is still open. A number of empirical studies suggest that a gender gap in competitiveness is likely to emerge in particular circumstances, such as a promotion tournament, where the pressure to succeed is high. An equally large number of studies using data from ‘real-life experiments’ find no statistically significant gender differences. These studies argue that controlled laboratory experiments provide an ideal setting to obtain undistorted measures of behavioral differences between men and women in competitive environments.

Finally, an already large and still increasing number of publications use data from professional sports to analyze and explain gender differences of highly self-selected athletes with similar aspirations and ‘competitive motivations’. Sports data are particularly useful as they are available in the form of byproducts of today’s comprehensive sports coverage (see Frick, 2004). Notwithstanding their respective merits, all three strands of literature suffer from major shortcomings, which, in turn, might explain the difficulties to reach a consensus in answering one of the presumably most pertinent questions in the field of gender economics.

14.2.1 Real-life Evidence

Using real-world data drawn from ‘natural experiments’ a number of studies find considerable gender differences in risk taking and performance under competitive pressure. Analyzing quantitative data obtained from test scores of Czech students applying to tuition-free selective universities, Jurajda and Münnich (2008, 2011) find that women perform significantly worse than equally able men in competitive situations. Since the women in their sample do not shy away from self-selecting into highly

competitive admissions programs, the authors reject differences in risk aversion as a possible explanation for the gender gap in test performance.

In a similar study, Ors et al. (2008) reach the same conclusion by showing that the performance of female applicants on admission tests at an elite French university is significantly lower than the performance of male applicants. Again, differences in risk aversion and ability cannot explain the observable pattern, because women perform significantly better in high-school exams as well as during their first year at the university, suggesting that women tend to ‘choke’ in competitive environments.

Attali et al. (2010) compare the performance in a standardized test (the Graduate Record Examination: GRE) that is used by many graduate schools in the US as a selection tool, with the performance in an experimentally designed second GRE taking place immediately after the ‘real’ test. The authors document a greater gender gap in performance in the competitive ‘real’ GRE than in the experimental GRE, which they attribute to men’s performing better ‘when it counts’, that is, when the stakes are particularly high.

Price (2008) examines how students at various high-ranked academic institutions in the US respond to the Mellon Foundation’s Graduate Education Initiative, a competitive scholarship program that was initially designed to encourage students to make quick progress towards their degree. As a result, the time to candidacy was statistically significantly reduced for male, but not for female students. Moreover, the reduction in time to candidacy was greater for both males and females when a larger fraction of the competing cohort was female.

In a different type of study, Hogarth et al. (2012) find gender differences in competitive situations which they attribute to differences in risk tolerance. Exploiting the natural experiment of a TV game show, where candidates answer questions similar to the ones that are known from the board game Trivial Pursuit in multiple rounds, the authors reveal that women earn 40 percent less than male contestants and exit the game voluntarily and earlier than men, particularly when women are in the minority.¹ Corroborating the latter result, Neelakantan (2010) finds that approximately 10 percent of the gender gap in accumulated wealth of elderly Americans (\$194,000 for men and \$95,000 for women) can be attributed to differences in risk taking, as women prove to be more conservative investors with a significantly lower probability to invest in stocks.

However, a number of studies find no persistent behavioral gender differences in competitive behavior and thus stand in stark contrast to the findings presented so far. Using data from the British Workplace Employees Relations Survey, Manning and Saidi (2010) analyze earnings and work effort under performance pay and find very modest (if any)

evidence for gender differences with respect to sorting into performance pay. Moreover, they find only a small effect of performance pay on earnings, which does not significantly differ by gender. Delfgaauw et al. (2009) conduct a field experiment in a Dutch retail chain consisting of 128 stores. Following the introduction of short-term sales competitions among randomly chosen subsamples of these stores, they find large positive effects on sales growth, but only in stores where the manager and a large fraction of the workforce are of the same gender. That is, shops with mostly female staff and a female manager improve their performance under competitive pressure to the same extent as male-dominated shops with a male manager. Interestingly enough, these results hold true even in the absence of any monetary rewards, suggesting a high symbolic value of winning a tournament.²

In a similar academic setting as in the studies by Jurajda and Münnich (2008, 2011) and Ors et al. (2008), documenting the existence of a considerable gender performance gap in highly competitive and stressful situations, Leuven et al. (2011) find no gender differences in either sorting or performance among male and female students in an introductory microeconomics course. In a study of teachers in Israel, Lavy (2008) finds that the performance of mathematics and language teachers is affected by neither the introduction of competitive elements in the remuneration process nor the gender composition of the group of teachers at a particular school. Following the introduction of a performance-related bonus system, neither the average rank nor the probability of winning a prize or the size of the prize differs by gender. Moreover, the gender composition of the groups of teachers competing with each other does not affect the performance of female teachers.

Exploring gender differences in risk aversion and negotiating practices, Feidakis and Tsaoussi (2009) compare the behavior of Greek attorneys, Greek business students and a control group consisting of young employees in public and private organizations. They find no statistically significant gender differences among attorneys and conclude that gender differences are unlikely to occur in groups of employees with a distinct professional culture.

14.2.2 Laboratory Experiments

Recently, the general finding that women perform worse under pressure than men has been challenged in a number of laboratory experiments. Shurchkov (2008) asked students to perform a verbal task (generally considered to favor women) under different conditions. The participants were divided in groups of four and required to solve word-in-word puzzles

in a limited amount of time.³ To examine the influence of competitive pressure on participants, the experiment was conducted in two stages. In the first round, a piece-rate scheme was used to reward the participants. Participants solved their tasks in a non-competitive environment, as their compensation was determined by their absolute rather than their relative performance. In the second round, a winner-take-all tournament rewarded only the winner of each group, while the other group members did not receive any compensation for their efforts. The behavior of male and female participants proved to be similar in the non-competitive as well as in the tournament setting. Moreover, neither men nor women improved their performance as a result of competitive pressure. Hence, Shurchkov (2008) finds no evidence that women underperform relative to men in a competitive environment. In a more recent study, Shurchkov (2012) examines two task stereotypes (math exercises versus verbal tasks) under different competitive regimes and time constraints and finds that men outperform women in a high-pressure math tournament while women succeed in a low-pressure verbal test.

Much in line with these latter results, Dreber et al. (2011) find no difference in performance under competitive pressure of 7–10-year-old boys and girls in Sweden. Following the initial research conducted with 9–10-year-old schoolchildren in Israel by Gneezy and Rustichini (2004),⁴ Dreber et al. replicated the field experiment with children from 11 primary schools in the Stockholm area. In addition to competing in a short distance race, the children engaged in rope skipping and modern dancing, two tasks that were deliberately chosen as they are perceived to be advantageous for girls. In the first round of the experiment, the children performed the task alone with no direct competition. In the second round, the children were matched in pairs according to their performance in the first round. As expected, the boys on average ran faster while the girls performed better in rope skipping and dancing. However, Dreber et al. found no differences in the performance under competitive pressure between boys and girls.

A possible explanation for the contradictory results of the two studies is that children in rather male-dominated societies (for example, Israel) experience different socialization and nurture than children in a more gender-equal society (as in Sweden). In a similar spirit, Cárdenas et al. (2011) examine gender differences in competitiveness and risk taking among children aged 9–12 in Colombia and Sweden, two countries ranked 55th and 4th in terms of gender equality according to various macroeconomic indicators. Surprisingly, boys and girls proved to be equally competitive in all tasks in Colombia whereas the results for Sweden were mixed. However, girls are more risk averse in both countries, with a smaller gender gap in Sweden. Finally, Ivanova-Stenzel and Kübler (2011) examine whether the

gender gap in performance depends on the gender composition of teams by introducing a real-effort task with wages either based on the teams' absolute performance or on the teams' relative performance in a competitive setting. The results suggest that, relative to a single-sex setting, gender diversity decreases the gender gap in performance in a competitive environment, while the gap increases in a non-competitive setting.

Another finding that emerges from a number of experimental studies is that women shy away from competition. Niederle and Vesterlund (2007) find that, when having the choice between performing a real task in a competitive setting in which the reward is based on one's relative performance (as in a rank-order tournament) versus a non-competitive environment, such as a piece-rate scheme that rewards one's absolute performance regardless of the performance of others, twice as many men as women self-select into the tournament (for similar findings, see Kamas and Preston, 2009; Vandegrift and Yavas, 2009; and Datta Gupta et al., 2011). Since the performances of men and women in the two different settings are similar, men apparently tend to enter tournaments too often while equally able women shy away from them too often.⁵

Examining the competitive choices of girls from single-sex and coeducational schools, Booth and Nolen (2012) find that girls from single-sex schools behave more like boys when randomly assigned to mixed-sex experimental groups, providing evidence for socially caused gender differences rather than inherent gender traits. Drawing on the allegedly immense differences in matrilineal and patriarchal societies, a number of studies have examined gender differences in competitiveness within these natural settings. Gneezy et al. (2009) examine the competitiveness of men and women in two societies, the Massai, a patriarchal society in Tanzania, and the Khasi, a matrilineal society in Northeast India. They find that in the patriarchal Massai society the gender gap is similar to that in Western societies. However, the gender gap is reversed in the matrilineal society, as women are found to be more competitive than men. Andersen et al. (2011) compare the competitiveness of children in patriarchal and matrilineal societies and show that the gender differences in competitiveness start to evolve around puberty, with the more pronounced changes occurring in the patriarchal society. For additional studies using data from matrilineal and patriarchal societies see, for example, Andersen et al. (2008), Gong and Yang (2011), and Hoffman et al. (2011).

14.2.3 Sports Data

Sports data are particularly well suited to explore gender differences in competitive behavior. First, professional athletes represent a highly

self-selected sample of persons with competitive motivation, enabling researchers to analyze gender differences among homogeneous individuals with a distinct professional attitude. Second, since the contestants have very specific *ex ante* information about prize structures and their opponents' abilities, the self-selection process as well as the incentive effects of tournaments can be examined in detail. Moreover, the high degree of transparency of the athletes' performances and capabilities is likely to reduce gender differences in overconfidence, which, in turn, might lead to a reduction in the gender gap in competitiveness (Frick 2011a, 2011b).

Garratt et al. (2011) examine the self-selection process of male and female runners in the 'State Street Mile', a running event that offers its participants the choice between a less competitive race without any prize money and a more competitive one with prize money. The authors find that qualified women and older runners are less likely to choose the competitive race than qualified young men. The fastest younger women, however, being aware of their abilities, do not shy away from competition, as they always enter the more competitive race. These results are consistent with Nekby et al. (2008) who find that, in an elite 10,000-meter race in Sweden, women are at least as likely as men to self-select into starting groups that are beyond their current physical abilities, suggesting that within the latter groups, overconfidence is equally likely for men and women.

Frick and Klaeren (1997) and Frick (1998) examine how male and female professional marathon runners respond to changes in prize money and prize structure. They find that women respond more to an increase of the total purse as well as to changes in its distribution, while their performance (that is, their finish time) is unaffected by bonus payments.⁶

These behavioral differences can be explained by the fact that the elite female marathon runners at that time (in the 1980s and early 1990s) were more heterogeneous (that is, less balanced) than the male elite runners. Due to that heterogeneity and an equal number of lucrative races for men and women, the top female athletes were initially able to avoid competing against each other by strategically entering certain events only. Thus, it was possible for a woman, but not for a man (who, due to the greater homogeneity in the field, always faced competitors of similar strength) to win a marathon with a 'suboptimal' performance (that is, a time that is well above the world record). However, over time, the gender gap in competitive balance has considerably narrowed, especially in long-distance and ultramarathon running. It appears that the most prestigious (and most lucrative) women's races (5,000m track, 10,000m road, half marathon and marathon) have been particularly 'balanced' throughout the

period of observation of nearly 40 years (see, for example, Frick 2011a, 2011b).

Using a similar approach but different data, several studies explore the response of professional tennis players to ‘competitive pressure’. Paserman (2007) analyzes set-level data from Grand Slam tournaments and finds that, for both men and women, the quality of the game deteriorates with increasing stakes. This deterioration in performance is greater for women in the decisive set, albeit not statistically significant. Yet, when examining point-by-point data, Paserman (2010) finds that women, but not men, are more likely to produce ‘unforced errors’ at crucial points of the match. Hence, there is evidence of a statistically significant gender gap in performance under pressure, even among highly self-selected persons. Sunde (2009) uses data from the final two rounds of all ATP (Association of Tennis Professionals) Master and Grand Slam tournaments in the years between 1990 and 2002 to analyze the behavior of male tennis professionals. He finds that in uneven contests both the favorite and the underdog perform worse than in ‘balanced’ contests, supporting the incentive hypothesis. Lallemand et al. (2008) find exactly the opposite result for female tennis players, as a greater difference between the two contestants results in a larger number of wins by the favorite and a larger number of losses by the underdog, which is in line with the capability hypothesis.⁷

Ehrenberg and Bognanno (1990a, 1990b) find that the overall prize money as well as its distribution have a significant impact on player performance in professional golf. The higher the total purse and the larger the prize differential, the lower are the scores and thus the better is the performance of an individual golfer. In addition, it appears that a golfer’s performance during the last round is positively correlated with the marginal returns to effort (that is, the higher the rewards for improving one’s rank) the smaller the number of strokes required to finish that particular round. However, replicating that study with comparable data from the Ladies’ Professional Golf Association (LPGA) Tour in the year 2000, Matthews et al. (2007) are unable to confirm the results of Ehrenberg and Bognanno for female players. They show that an increase of the total purse leads to higher scores, signifying weaker performance. A possible explanation for the observed gender differences in performance is that women are likely to succumb to the pressure that comes with large prizes at stake (that is, ‘choking under pressure’), whereas men respond positively to an increase of prizes by delivering a better performance.

Table 14.1 Overview of the datasets

Type of data	Performance level		
	International	National	Regional
Annual Top 100 Best Lists 2001–2010	X		
Annual Top 50 Best Lists 2001–2010	X	X	
Finishing Times in Finals (Top 5) 2001–2010	X	X	X

14.3 DATA AND DESCRIPTIVE EVIDENCE

Our estimation uses four different datasets. The first one includes the top 100 male and top 100 female athletes worldwide in the years 2001–10 at the 100m distance, the most popular short-distance race in the world. The size and the structure of the datasets are displayed in Table 14.1. The data are assembled and constantly updated by a group of formerly competitive long-distance runners who are also devoted statisticians. The data can be accessed on their website (www.arrs.net). Since all relevant information on these top-100 male and female performers (name, date of birth, nationality, finish time, date and place of competition) is available for 10 years, the total number of observations is 2,000. The second dataset is very similar to the first one and includes the top 50 male and female German sprinters at the same distance during the same time period ($n = 1,000$). The data for Germany are assembled and constantly updated by the German Track and Field Association and can be retrieved from their website (www.deutscher-leichtathletik-verband.de). In our third dataset we merge the top 50 international athletes with the top 50 national athletes of both genders, again yielding 2,000 observations.

Using the first two datasets, we calculate the time difference between men and women of the same rank for each of the ten years.⁸ To ensure comparability, we calculate the difference not in seconds, but the percentage difference of the respective man and woman's performances (for an illustration see Table 14.2):

$$PD = [(FFT_{ij} - MFT_{ij}) / MFT_{ij}] * 100, \quad (14.1)$$

where:

- PD*: percentage difference in finishing times;
- FFT*: female finishing time in year i and on rank j ; and
- MFT*: male finishing time in year i and on rank j .

Table 14.2 An illustration of dataset 1

Year	Category	Rank	Male athlete	Time	Time difference (in %)	Female athlete	Time
2008	Intern'tl	1	Usain Bolt	9.69	11.25	Torri Edwards	10.78
		2	Asafa Powell	9.72	10.91	Shelly-Ann Fraser-Price	10.78
		3	Tyson Gay	9.77	10.54	Kerron Stewart	10.80
...		...					
...	National	98	Rolando Palacios	10.22	11.15	Monique Henderson	11.36
		99	Justyn Warner	10.23	11.05	Chalonda Goodman	11.36
		100	Peimeng Zhang	10.23	11.05	Tahesia Harrigan	11.36
...		...					
2010	National	1	Tobias Unger	10.14	9.47	Verena Sailer	11.10
		2	Alex. Kosenkow	10.26	10.43	Anne Möllinger	11.33
		3	Marius Broening	10.26	10.43	Yasmin Kwadwo	11.33
...		...					
		48	Korbinian Greding	10.76	11.52	Katharina Grompe	12.00
		49	Eric Franke	10.76	11.71	Franziska Dobler	12.02
		50	Timo Stinski	10.76	11.80	Sinje Florczak	12.03

Source: Association of Road Running Statisticians (www.arrs.net) and own calculations.

Table 14.3 An illustration of dataset 2

Category	Rank	Name	Time	Year	Event	Sex	Var. coeff.
International	1	Usain Bolt	9.58	2009	World Championship	1	0.013835
International	2	Tyson Gay	9.71	2009	World Championship	1	
International	3	Asafa Powell	9.84	2009	World Championship	1	
International	4	Daniel Bailey	9.93	2009	World Championship	1	
International	5	Richard Thompson	9.93	2009	World Championship	1	
International	1	Shelly-Ann Fraser	10.73	2009	World Championship	0	0.010153
International	2	Kerron Stewart	10.75	2009	World Championship	0	
International	3	Carmelita Jeter	10.90	2009	World Championship	0	
International	4	Veronica Campbell-Brown	10.95	2009	World Championship	0	
International	5	Lauryn Williams	11.01	2009	World Championship	0	
...							
National	1	Tobias Unger	10.20	2008	Nat. Championship	1	0.004783
National	2	Stefan Schwab	10.29	2008	Nat. Championship	1	
National	3	Martin Keller	10.32	2008	Nat. Championship	1	
National	4	Alexander Kosenkow	10.33	2008	Nat. Championship	1	
National	5	Ronny Ostwald	10.33	2008	Nat. Championship	1	
National	1	Verena Sailer	11.28	2008	Nat. Championship	0	0.008837
National	2	Cathleen Tschirch	11.45	2008	Nat. Championship	0	
National	3	Anne Möllinger	11.48	2008	Nat. Championship	0	
National	4	Marion Wagner	11.54	2008	Nat. Championship	0	
National	5	Karoline Köhler	11.57	2008	Nat. Championship	0	
...							

Table 14.3 (continued)

Category	Rank	Name	Time	Year	Event	Sex	Var. coeff.
Regional	1	Christian Blum	10.40	2007	Bavarian Championship	1	0.021153
Regional	2	Marco Thomann	10.81	2007	Bavarian Championship	1	
Regional	3	Lasse Zunker	10.88	2007	Bavarian Championship	1	
Regional	4	Gerald Stürzenhof	10.96	2007	Bavarian Championship	1	
Regional	5	Florian Prockl	11.07	2007	Bavarian Championship	1	
Regional	1	Susi Zimanyi	11.93	2007	Bavarian Championship	0	0.013561
Regional	2	Franziska Bertenbr	11.97	2007	Bavarian Championship	0	
Regional	3	Hacker Hanne	12.05	2007	Bavarian Championship	0	
Regional	4	Stefanie Staudacher	12.19	2007	Bavarian Championship	0	
Regional	5	Pamela Spindler	12.38	2007	Bavarian Championship	0	

Sources: the-sports.org (<http://www.the-sports.org/athletics-s5-c0-b0.html>), as well as leichtathletik.de (<http://www.leichtathletik.de/index.php?SiteID=16>) and own calculations.

Source: Global Annual Ranking, 2001–2010.

Figure 14.1 Percentage difference in finish times between male and female athletes by rank

In our estimations – presented in Section 14.4, below – we use the percentage time difference between a male and a female runner at the same rank in the annual (international or German) best list as the dependent variable. If – as suggested by most of the available literature from Section 14.2 – female athletes exhibit a lower degree of competitiveness, the time difference will increase from rank to rank. If, on the other hand, women exhibit a similar degree of competitiveness, the time difference will be more or less constant across the ranking.

Figures 14.1 and 14.2 illustrate equation (14.1) for international and German athletes. The broken lines in the figures show the actual (averaged) observations for the years 2001 to 2010, while the black lines show the fitted values. They reveal that a concave trend represents the observable pattern quite well: the percentage difference in the top performances of male and female sprinters increases monotonically, but with a lower slope in the international data than in the national (German) data. Interestingly, the percentage difference in finish times in the global ranking decreases in the top ranks, suggesting that the performance of the top five of the female elite is more homogeneous than the top five of the male elite. This may be because of the dominance of a single runner among men, the ‘Usain Bolt effect’.

Apart from the observable differences in the degree of competitiveness between men and women, the size of the population of male and female

Source: German Annual Ranking, 2001–2010.

Figure 14.2 *Percentage difference in finish times between male and female athletes by rank*

runners is likely to affect the average performance of those making it into the ‘Top 50’, as measured by the mean finish times in Figures 14.1 and 14.2. Population size is also likely to affect the dispersion of the performances of the top athletes, which we measure with the coefficient of variation of the top 50 performers in both a small country like Germany and the world. It appears from Figures 14.3 and 14.4 that the dispersion in the large international population is far smaller than in the small national population and that this difference is much larger in the case of women. The fact that the difference in average performance and in performance dispersion between the small and the large pool is far lower for men than for women has two implications. First, the histories of professional track and field athletics are quite different for men and for women (a phenomenon that is usually referred to as ‘path dependency’; for a detailed discussion in the sports context, see Frick, 2011b). Second, certain thresholds may exist, beyond which an increase in the number of competitors is unlikely to increase the average quality of the contestants significantly.⁹

Our fourth dataset is different from the first three. It includes the five top finishers in the 100m finals at international,¹⁰ national, and regional championships¹¹ over the 2001–10 period both for men and women (Table 14.4). Using the finish times of the five top performers we first calculate the coefficient of variation to determine the ‘closeness’ or the

Figure 14.3 Coefficient of variation of the performance of male sprinters, 2001–2010

Figure 14.4 Coefficient of variation of the performance of female sprinters, 2001–2010

‘competitive balance’ of these races. We then use these figures in an analysis of variance to check whether competitiveness among male and female athletes differs among the three levels.¹²

It appears from Table 14.4 that – as expected – the coefficient of variation is much lower for men than for women and far higher at the regional and – to a lesser extent – the national level. These results are consistent with the ones reported above and lend further support to the hypothesis that women exhibit a lower degree of competitiveness than men.

Table 14.4 Analysis of variance of male and female athletic performance

	Var. coef.	Std dev.	No. of observations	F-value
International				
Women	0.84	0.36	59	1.45 ⁺
Men	0.76	0.34	59	
National				
Women	1.02	0.30	9	10.31***
Men	0.63	0.21	9	
Regional				
Women	1.94	0.85	54	13.93***
Men	1.42	0.56	54	

Note: ⁺ Not significant; *** $p < 0.01$.

14.4 ECONOMETRIC FINDINGS

Figures 14.1 and 14.2 suggest a relationship between rank and competitiveness, but they do not give the precise relationship, nor do they account for other factors that might affect competitiveness. To state the relationship between rank and competitiveness more precisely, we estimate the following regression model separately for international and national runners, using our first two datasets separately (to ensure robustness of standard errors, we always bootstrap with 200 replications):

$$PD_{ij} = \alpha_0 + \alpha_1 RANK_{ij} + \alpha_2 RANK_{ij}^2 + \alpha_3 TT + \varepsilon_{ij}, \quad (14.2)$$

where:

- PD_{ij} : percentage difference in finishing time between female and male runner on rank i in year j ;
- $RANK$: position of runner i in year j in annual ranking; and
- TT : linear time trend (2001 = 1, . . . , 2010 = 10).

The second regression model uses both datasets simultaneously and includes in the estimation two interaction terms to account for possible differences between the international and national levels as well as a multiplicative combination (that is, an interaction term) of the national dummy and the linear time trend:

$$PD_{ij} = \alpha_0 + \alpha_1 RANK_{ij} + \alpha_2 RANK_{ij}^2 + \alpha_3 NAT_RANK_{ij} + \alpha_4 NAT_RANK_{ij}^2 + \alpha_5 TT + \alpha_6 NAT_TT + \varepsilon_{ij}, \quad (14.3)$$

where:

- PD_{ij} : percentage difference in finishing time between female and male runner on rank i in year j ;
 $RANK_{ij}$: position of runner i in year j in annual ranking (ranging from 1 to 50; including squared term);
 TT : linear time trend (2001 = 1, . . . , 2010 = 10);
 NAT_RANK : multiplicative combination of German dummy and rank (including squared term); and
 NAT_TT : multiplicative combination of German dummy and linear time trend.

It appears from Table 14.5 that – corroborating the impression generated by Figures 14.1 and 14.2 – the percentage difference in the finish times between men and women at the same rank increases with rank, albeit at a declining rate, suggesting that the pool of female runners is still more heterogeneous than the pool of male runners. Moreover, the coefficient of the linear time trend is positive and statistically significant in both estimations, which implies that the performance differential between men and women increases as time progresses. Finally, these effects are far stronger in the national (German) sample than in the international sample. Thus, the evidence presented so far is not consistent with any of the hypotheses held by psychologists, medical scientists, sociologists, or economists, as all four suggest that differences between the sexes should be declining over time, albeit for different reasons.

These results are completely at odds with the findings reported in two companion papers using data from long- and ultra-distance running (Frick 2011a, 2011b), which document a significant decrease in the performance differential over time. We cannot rule out the possibility that these different developments are caused by the frequency and rigor of drug-testing. On the one hand, women benefit far more from using steroids and testosterone than men. On the other hand, these substances are far easier to detect than, for example, very small doses of EPO, a drug that is preferred by long-distance runners. Thus, the increasing performance differential is most likely caused by the recent decline in the use of performance-enhancing drugs by top female athletes (for a similar argument, see, for example, Seiler et al., 2007).¹³

Given the increasing performance differential between male and female sprinters, ordinary least squares (OLS) may not be the appropriate estimation technique if the impact of the position in the annual ranking is not constant across the distribution. Since this problem has been acknowledged in the sports economics literature by many researchers, some of

Table 14.5 *Estimation results*

	Coefficient	Std error	<i>t</i>	<i>P</i>
Model 1: International Sample (Worldwide)				
<i>RANK</i>	0.01752	0.00128	13.65	***
<i>RANK</i> ² #	-0.00911	0.00123	-7.40	***
<i>TT</i>	0.19282	0.00302	-6.39	***
Constant	-28.37846	6.05049	-4.69	***
No. of obs.		1,000		
Replications		200		
Wald Chi ²		220.8		
<i>R</i> ² * 100		43.8		
Model 1: National Sample (Germany)				
<i>RANK</i>	0.06099	0.00677	9.00	***
<i>RANK</i> ² #	-0.09047	0.00114	-7.91	***
<i>TT</i>	0.01545	0.00605	2.55	**
Constant	-20.29035	12.14130	-1.67	*
No. of obs.		500		
Replications		200		
Wald Chi ²		117.1		
<i>R</i> ² * 100		33.0		
Model 2 (Pooled Data including International and National Top 50)				
<i>RANK</i>	0.02066	0.00465	3.52	***
<i>RANK</i> ² #	-0.01253	0.00884	-1.25	+
<i>NAT_RANK</i>	0.04036	0.00657	4.43	***
<i>NAT_RANK</i> ²	-0.00078	0.00013	-5.08	***
<i>TT</i>	0.02734	0.00393	6.93	***
<i>NAT_TT</i> #	0.02170	0.00363	5.98	***
Constant	-44.58343	7.89106	-5.65	***
No. of obs.		1,000		
Replications		200		
Wald Chi ²		1,894.2		
<i>R</i> ² * 100		62.3		

Note: +Not significant; * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

them now use quantile regression estimation (see, for example, Hamilton, 1997; Berri and Simmons, 2009; and Vincent and Eastman, 2009) in the case that the dependent variable (for example, log of player salary) has a particularly large kurtosis.¹⁴ Of course, OLS is the best linear unbiased estimator provided that the error distribution is homoskedastic, and OLS

parameters tend to a normal distribution around true values even if the individual residuals are not normally distributed. However, OLS constrains the marginal effects of covariates to be the same throughout the conditional distribution of the performance, which is not necessarily the case. Therefore, we investigate the impacts of rank at various quantiles of the conditional performance distribution, not just the conditional mean. To ensure robustness of standard errors, we again bootstrap with 200 replications.

It appears from Table 14.6 that the impact of *RANK* on the performance differential between male and female athletes is decreasing across the quantiles of the distribution. Again, this finding is at odds with the results reported in Frick (2011a, 2011b), where the coefficients appear to be remarkably constant. We are tempted to attribute this somewhat unexpected result to the different costs and returns to using illegal substances. It is particularly worth noting that the coefficients of the trend variable differ considerably across the quantiles as well as between the international and national samples. This suggests that the observable increase in the gender gap in performance has been much stronger in the small pool (that is, in Germany). It also suggests that this increase has been particularly large among the less talented athletes. These findings are again neither consistent with the ‘culture-and-incentives hypothesis’ nor with the ‘biology-and-predispositions hypothesis’.

14.5 CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

The evidence from 100m races presented in this chapter is not fully compatible with any of the four competing explanations. However, competitive pressure seems to affect performance equally for men and women. Irrespective of gender, the coefficient of variation in the annual top performances is smaller in a large (world) population than in a small population (Germany). As a result, we favor the sociological and economic ‘culture-and-incentives’ hypotheses, according to which athletes become more competitive if they are socialized and incentivized to compete and have opportunities to do so. Perhaps surprisingly, competitiveness has decreased among women in recent years, which is at odds with all four hypotheses and seems to imply that the use of illegal substances has declined more among women than among men.

These results notwithstanding, additional tests of the ‘culture-and-incentives’ hypothesis can – and should – be performed to add further support. First, the increasing ‘cultural heterogeneity’ of the top runners is

Table 14.6 *Quantile regression*

	Quantile				
	0.10	0.25	0.50	0.75	0.90
International (Top 100)					
<i>RANK</i>	0.0303*** (13.85)	0.0234*** (12.60)	0.0142*** (9.50)	0.0123*** (4.45)	0.0091*** (3.86)
<i>RANK</i> ² #	-0.0192*** (-10.04)	-0.0132*** (-8.69)	-0.0068*** (-5.51)	-0.0053* (-1.81)	-0.0023+ (-1.19)
<i>TT</i>	0.0222*** (3.55)	0.0044* (1.93)	0.0004+ (0.12)	0.0270*** (3.75)	0.0314*** (9.53)
Constant	-34.790** (-2.78)	1.215+ (0.27)	9.630* (1.67)	-43.540*** (-3.02)	-52.070*** (-7.86)
National (Top 50)					
<i>RANK</i>	0.0440*** (7.37)	0.0347*** (5.96)	0.0181** (2.10)	0.0130* (1.93)	-0.0022+ (-0.34)
<i>RANK</i> ² #	-0.0410*** (-4.04)	-0.0279*** (-3.02)	-0.0130+ (-0.88)	-0.0057+ (-0.48)	0.0188* (1.71)
<i>TT</i>	0.0419*** (4.77)	0.0251*** (6.10)	0.0093+ (0.89)	0.0383*** (5.29)	0.0480*** (8.20)
Constant	-74.48*** (-4.24)	-40.53*** (-4.91)	-8.36+ (-0.40)	-66.11*** (-4.56)	-85.32*** (-7.27)
Pooled (Top 50)					
<i>RANK</i>	0.0440*** (6.79)	0.0347*** (5.52)	0.0181** (2.34)	0.0130* (1.88)	-0.0022+ (-0.29)
<i>RANK</i> ² #	-0.0410*** (-3.69)	-0.0279*** (-2.77)	-0.0130+ (-0.95)	-0.0057+ (-0.49)	0.0188+ (1.43)
<i>NAT_</i> <i>RANK</i>	0.0380*** (3.73)	0.0311*** (3.11)	0.0268*** (2.64)	0.0043+ (0.43)	0.0086+ (0.81)
<i>NAT_</i> <i>RANK</i> ² #	-0.0672*** (-3.79)	-0.0603*** (-3.76)	-0.0533*** (-3.02)	-0.0154+ (-0.93)	-0.0250+ (-1.43)
<i>TT</i>	0.0419*** (4.85)	0.0251*** (6.33)	0.0093+ (0.98)	0.0383*** (5.43)	0.0480*** (9.31)
<i>NAT_TT</i>	0.0036+ (0.30)	-0.0031+ (-0.29)	-0.0054+ (-0.47)	-0.0398*** (-3.99)	-0.0467*** (-5.98)
Constant	-74.48*** (-4.30)	-40.53*** (-5.09)	-8.37+ (-0.44)	-66.11*** (-4.67)	-85.32*** (-8.27)

Note: + Not significant; * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; # Multiplied by 100 for presentational purposes.

likely to affect the degree of competitiveness of both men and women, as it increases both the size and the composition of the pool of athletes. Male sprinters from the US ceased dominating international competition in the 1980s, but US women held sway for a longer period. In the last several decades, the percentage of world-class athletes has increased considerably among both sexes, particularly from the Caribbean and among women.

Thus, the disproportional increase in the number of athletes from Central and South America may have intensified the competition among women more than among men. Second, since comparable data are available for other events in track and field, the empirical analyses can – and should – be extended. Apart from middle- and long-distance races that have already been analyzed in detail, track and field events include a number of other disciplines – such as throwing and jumping – where the gender gap in world records is considerably larger (at 15–18 percent compared to 10–12 percent in distance running).

So far, there has been no comparable empirical analysis of gender differences in competitiveness in such field events as shot put, discus, javelin and hammer throw, high jump, pole vault, long jump, and triple jump. The observable differences in competitiveness between the track events on the one hand and the field events on the other may be due to biological factors that make women relatively better at running. Another possible explanation is that fewer women choose to engage in field disciplines which, in turn, are likely to result in a lower degree of competitiveness. Unfortunately, the data that are available on the top performers and/or the top performances in the throwing and the jumping disciplines are not as complete as they are for the running disciplines (see, for example, www.iaaf.org). It does appear, however, that, with the exception of long jump, far fewer female athletes are responsible for the 100 best performances in a given year as well as the all-time best performances than the respective number of male athletes. This suggests that there is a higher degree of ‘performance concentration’ and a lower level of competitiveness among women.

NOTES

1. Using data from the TV game show ‘The Weakest Link’, Antonovics et al. (2009) find that women’s likelihood of correctly answering a question is unaffected by the opponent’s gender whereas men are more likely to give a correct answer when competing against a woman. Säve-Söderbergh and Lindquist (2011) analyze the behavior of women in the game show ‘Jeopardy’ and find that irrespective of any strategic gains, women play more conservatively when facing male competitors only.
2. Furthermore, this assumption is supported by the fact that despite the considerable variation in team size the authors are unable to find any evidence for free riding.
3. In a word-in-word puzzle, the objective is to form as many words as possible from the letters of another long word.
4. The children had to run a distance of 40 meters twice, first alone and then matched with a child of equal ability. While boys increased their effort (that is, ran faster) in a competition, the girls’ performance was unaffected by the setting.
5. See also Price (2009), Balafoutas and Sutter (2010), Cason et al. (2010), Niederle et al. (2010), Sutter and Rützler (2010), Wozniak et al. (2010), Healy and Pate (2011), and, using data from professional tennis players, Wozniak (2012). A notable exception is Price (2010) who uses a similar experimental design but fails to find gender differences

in competition aversion. This is mainly because the participants in this study did not display any gender difference in confidence, which is considered more important in explaining gender differences in competitiveness than differences in risk preferences, as examined in numerous experimental studies (for example, Halko et al., 2008; Charness and Gneezy, 2010, and Garcia-Gallego et al., 2010, or, for a summary, Croson and Gneezy, 2009). A nice example for men's overconfidence is presented in Reuben et al. (2012). In a two-stage real effort task groups select a leader to compete against other group leaders. It is found that men are selected significantly more often as leaders than is suggested by their individual performance in the first stage and that this is mainly driven by men's overconfidence.

6. Bonus payments are typically rewards for beating certain finish times, such as the world or course record or pre-specified thresholds.
7. The capability hypothesis posits that differences in talent and abilities result in a high (low) probability of the favorite (the underdog) to win a contest. The incentive hypothesis states that greater heterogeneity among the players' *ex ante* abilities results in worse performance by both the favorite and the underdog, who assume that the outcome of the match is largely predetermined.
8. The kernel density estimation of the time difference is available from the authors upon request.
9. For a different approach to such gender differences, see, for example, Chapter 12 in this volume.
10. Here we include the Olympic Games, the IAAF World Championships as well as the Golden League and the Diamond League Meetings.
11. By 'regional championships' we mean the finals in the respective competition at the level of the federal states.
12. Since in some of the regional championships only five athletes participated in the finals, we had to restrict our analysis to the top five finishers.
13. This does not imply that the use of illegal substances has declined in general, but that the 'old stuff' has been replaced by more effective and more difficult to detect performance-enhancing drugs.
14. Presence of non-normality in the dependent variable is indicated by a large kurtosis value and in our case the D'Agostino et al. (1990) test is performed by the *sktest* command in Stata 11. In the two datasets used here the kurtosis of the dependent variable (percentage difference in finishing times between female and male runner on the same rank in the annual top 100 and top 50) is 3.74 (national) and 3.39 (international).

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