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‘La Grande Boucle’:

Determinants of Success at the Tour de France

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Cycling has not been analyzed intensively in the economics of sports literature. This paper reports empirical evidence of individuals’ performances in the 2004 ‘Tour de France’. We investigate different performances such as total ranking, mountain ranking, time trial rankings as dependent variables and search for factors that shape riders’ performances. The results show that riders who were successful in previous Tours perform better than other participants. Team leaders are more successful, and a lower body-mass index leads to a better performance. We also observe differences among the participating countries. Finally, the results suggest that riders’ performances are influenced by their teammates.

JEL Classification codes: L830

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INTRODUCTION

The field of economics of sports has shown how effective traditional economic tools are to analyze sport events. The sports industry has grown and professionalism has increased. This development attracted the attention of academics who started to investigate sport events. More and more papers go beyond studying sport as an industry, but "examine the play of sports as an expression of rational human action subject to the relevant constraints" (Goff & Tollison, 1990, p. 3). Data sets are increasingly available and allow to investigate individual performances in detail. Compared to other "non-market economic topics", the investigation of sport events has several advantages (see, e.g., Goff & Tollison, 1990):

1) Reliability of data. Sports data have in general low variable errors. For example, the ranking of a cyclist, his performance in the mountains or the time trials are clearly observable and are free of discrepancies compared to well known and often used traditional economic variables such as GDP or CPI.
2) Availability of data: A huge amount of data is now available. New technologies such as the Internet allow to collect data at lower costs, as many event organizers provide statistical data. The organizers of the Tour de France publicize a huge amount of statistical material on their homepage www.letour.com, covering not only results but also cyclists' profiles which allows to account for the heterogeneity of riders. Assuming that athletes are homogenous was one of the major shortcomings in previous sport studies. Thus, new data sets allow to take into consideration that athletes have different abilities and physical conditions, different histories of performance, and different cultural backgrounds which could have an impact on their present and future achievements.
3) A Tour de France is close to a field experiment. The race takes place in a controlled environment. All riders perform in the same terrain at the same time with the same outside restrictions such as the weather. Further external influences are controlled by the rules (law) of the event, as they are the same for all riders. Thus, many factors can be held constant and the situation is much like a controlled environment. Even though a cyclist event allows social and economic interactions and is thus less controlled than a laboratory experiment (see Burtless, 1995 about the advantages and problems of randomized field trials), one of the main advantages is that the participation evokes actual and real processes in an environment outside a laboratory setting. Performing

well at the Tour de France is important for professional cyclists as their earnings and future value depend on it. Laboratory experiments induce lower economic or financial incentives than a real sport event. They certainly have the great advantage that a specific situation can be designed and thus the variables of interest can be controlled for and manipulated. This allows to reduce causality problems and thus gives sound information not only about the relationship between two variables but also about the direction of the effect. On the other hand, working with some sport data (e.g., performance, ranking as dependent variables) may reduce endogeneity problems arising with other field data.

The economics of sport literature mostly analyses sports such as soccer (e.g., Dobson & Goddard, 2001; Feess & Muehlheusser, 2003; Preston & Szymanski, 2001; Gius & Johnson, 2000; Hoffmann et al., 2002a; Houston & Wilson, 2002; Espitia-Escuer and García-Cebrián, 2004; Torgler, 2004a, 2004b, 2004c), baseball (e.g., Goff & Tollison, 1990; Jewell et al., 2004; Debrock et al., 2004), football (e.g., Grier & Tollison, 1994; Hendricks et al., 2003; Einolf, 2004), basketball (e.g., Kahn & Sherer, 1988, Grier & Tollison, 1990; Goff & Tollison, 1990; Burdekin & Idson, 1991; McCormick & Tollison, 2001; Yilmaz & Chatterjee, 2000), golf (e.g., Moy & Liaw, 1998; Shmanske, 2000; Chatterjee et al., 2002), hockey (e.g., Idson & Kahane, 2000; Kahane, 2001; Curme & Daugherty, 2004, Gandar, Zuber & Johnson, 2004) or tennis (see, e.g., Hamilton & Romano, 1998; Magnus & Klaassen, 1999). There is also an increasing interest to investigate the Olympics (see, e.g., Tcha, 2004, Bernard & Busse 2004, Hoffman et al., 2002b).

Research papers in economics of sport are predominantly North America oriented (see, e.g., Goff &Tollison, 1990; Kern, 2000; Fort, 2003). Certainly, American sports events offer a particularly splendid field for empirical studies, thanks to large and very well registered data sets. It is somehow surprising though that economists did not write more papers on other important sport events such as cycling. The Tour de France is one of the most important yearly sports events around the world. People have the possibility to watch athletes performing in a big open “earth stadium” of more than 3’000 km without having to pay for it, an opportunity every year millions of spectators take. The mountain time trial from Bourg-d’Oisans to L’Alpe d’Huez, for example, attracted over a million spectators.

This paper reports empirical evidence of individuals’ performances in the cycling event Tour de France with data for the year 2004. Section II introduces the Tour, presents a summary of the 91 Tour de France races between 1903 and 2004, giving also a short historical overview of major Tour events, and provides background information on the Tour de France 2004. Section III develops the model, gives information about the dependent and independent variables used and develops theoretically the predicted influences. Section IV presents the empirical results and Section V finishes with some concluding remarks.

THE EVENT: A BRIEF HISTORICAL OVERVIEW

The Tour de France is the world's most important cycling event, where the best athletes participate. Figure 1 presents a summary of all 91 Tour de France events between 1903 and 2004[1]. The first race held in 1903 had six stages covering a distance of almost 2'500 kilometers. 59 riders participated, to whom relatively rich prizes and bonuses were offered. The total prize money was 20'000 French Francs, the winner obtained 3'000 Francs. Already in 1903, all participants were professional or semi-professional cyclists. In 1906, the organizers increased the number of stages from 11 to 13 and the length from 3'000 to 4'500 km; in 1912, 2 more stages were added, covering now more than 5'000 km. While in 1912 131 team riders participated already, in 1925 the Tour had 209 contestants and was enlarged to 18 stages. In 1938 the individual category was abolished and replaced by three twelve-men teams representing France, Belgium, Germany and Italy and five six-men teams for Spain, Austria, Switzerland, Netherlands and Luxembourg. In 1962, the Tour allowed for the first time commercially sponsored teams, which led to the disappearance of national teams. The Tour 1966 was marked by the introduction of doping controls. The French rider Poulidor was the first to undergo anti-doping tests, but many other riders protested against it. In fact, most of the Italian participants boycotted the race. In 1977 and 1978, the Tour was interrupted by riders' strikes, who were frustrated by the reduction of recover time between the stages. The Tour 1987 had no less than 25 stages, but a record in the number of changes of leaders (9). In 1988 the Spanish rider Delgado, who was leading the Tour, had positive results in one out of ten anti-doping tests. Although the substance found was on the International Olympic Committee's list of prohibited substances, the International Cyclists Union (UCI) didn't sanction the rider, as they had not updated their list with this substance. In 1989 the Tour was won by the US cyclist Greg Lemond by a slight advance of 8s. 1998 was also marked by scandals, as one of the prominent teams (Festina) was suspended after French customs officers had found a stockpile of drugs and associated products. Another team (TVM) was taken in for questioning as one rider was accused of selling doping drugs to other riders. The

Tour was short from being cancelled and one stage had to be annulled because the *peloton* stopped the race several times to express their solidarity with the TVM riders. In the Tour 2000, the organization improved the anti-doping test (freezing urine samples for retesting possibilities in the future).

Figure 1 demonstrates that the average speed increased continuously, from 25.7 km/h in 1903 to 40.6 km/h in 2004, reaching the highest velocity in 2003 (41 km/h). The total distance of the race increased in the first 20 events from 2'428 to 5'745 km. Since then, we observe a decrease to around 3'500 km. The number of stages increased from 6 to around 20 and remained quite stable over time.

The most dominant riders in the history of the Tour have been (including 2004) Lance Amstrong (USA, 6 time winner), Miguel Induráin (Spain), Bernard Hinault (France), Eddy Merckx (Belgium) and Jacques Anquetil (France), all of them having won the Tour de France five times (see Official Tour de France Centennial 1903-2003).

In 2000, the total sum of prize money was of 1'850'000 EURO. Out of this money 831'300 EURO were paid to the cyclists based on their final ranking position. The winner of the Tour received 335'400 EURO, the best in the point ranking and the mountains ranking 22'870 EURO each and stage winners 22'516 EURO each. Further major rewards are given for team-ranking (total amount of 146'350 EURO), young-rider ranking (total= 45'735 EURO), most aggressive-ride ranking (51'830 EURO) (see www.cycling4all.com). Thus, a strong pecuniary incentive is provided to succeed in this race. Figure 1 presents the winners' prize money ratio (in %, winners prize money*100/ total prize money). In general, we observe a relatively high concentration of rewards to the winner of the Tour de France. The structure of the event is close to a winner-take-all market. The winner gets much larger earnings than the "losers". This is in line with the phenomenon of superstars, were a small number of people get enormous amounts of money compared to other athletes (see Rosen, 1981) and corresponds to a large number of professional sports and culture markets (see Frank & Cook, 1995). In 1937 the winner obtained 25% of the total amount of prize money. It is interesting to observe that in the first years of the event the winners obtained a high amount of the total prize money. Recent developments also show a relatively high concentration of prize money to the winner. But for a long period, the amount was never beyond 10% (between 1948 and 1987). Thus, the development of the winners' ratio over time is close to a U-shaped curve.

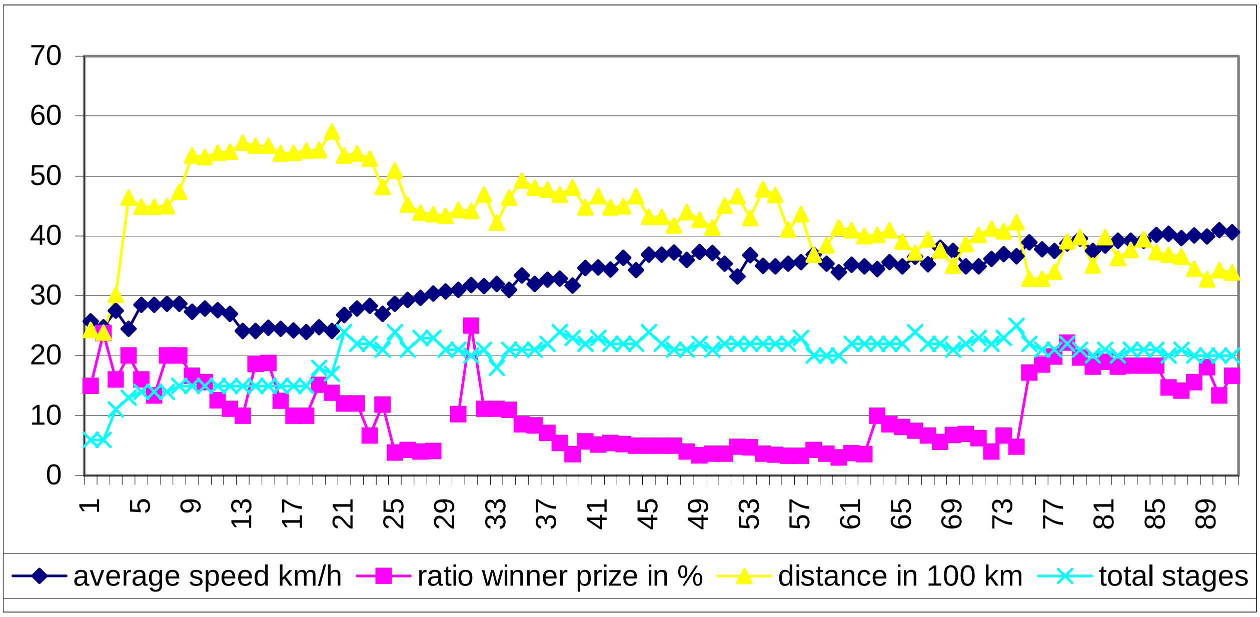

FIGURE 1: Summary of All the 91 Tour de France Events between 1903 and 2004

In this paper we use the newest data of the Tour de France 2004. The race took place in July (from Saturday July 3rd to Sunday July 25th) and consisted of one prologue and 20 stages covering a total distance of 3'390 kilometers. The 20 stages comprised 11 flat stages, 6 mountain stages, 2 individual time-trials and 1 team time-trial. Out of 6 mountain stages, 3 were mountain finishes. The two individual time-trials (without the prologue of 6.1 km) covered 70.5 kilometers, a mountains trial of 15.5 km and a general trial of 55.0 km. During the Tour, only 2 rest days were held. 21 teams with 188 cyclists were qualified to start. The teams were selected in two steps following the International Cyclists Union regulations (UCI). In a first step the 14 best teams of the UCI ranking system, based on the performance of the previous seasons, were automatically qualified. In a second step, 7 other teams entered thanks to wild cards. Out of the 188 riders, only 147 finished the Tour. The winner of the 2004 Tour received around 500'000 EURO and the total prize money for the race was around 3 million EURO (http://www.cyclingnews.com). The data used for the empirical analysis is available on the Tour de France official homepage (see www.letour.com).

MODEL

DEPENDENT VARIABLES

We use several dependent variables in our study. All measure cyclist's output (success) in different categories at the Tour de France 2004 such as total ranking, mountain ranking, and the time trials rankings. Using the ranking instead of the time difference as dependent variable is relevant, because many incentives such as the prize money are connected to the rank. Thus the order and not the distance between two riders matters[2]. We will use two models: ordered probit and OLS models. The ordered probit models help analyze the ranking information of the scaled dependent variables. As in the ordered probit estimation, the equation has a non-linear form; only the sign of the coefficient can be directly interpreted and not its size. Calculating the marginal effects is therefore a method to find the quantitative effect a variable has on the cyclists' performances. The marginal effect indicates the change in the share of riders (or the probability of) belonging to a specific ranking level, when the independent variable increases by one unit. However, an ordered probit is a little clumsy as originally we have not many observations in each ranking class. Thus, we also estimated OLS models. This has also the advantage to check the robustness of the results. The ranking classes for the ordered probit has been structured in a similar way for all dependent variables (see Table A1 in the Appendix). In all the estimations we present the marginal effects for the top group (best 25 rankings). In those estimations where all participants are considered, we also report the marginal effects of the lowest group (riders who did not finish the Tour or did not get mountain points). In the ordered probit estimations, a better performance goes in line with a classification in a higher group. On the other hand, the lower the values, the better the individual performance in the OLS estimations.

The individual performance can be modeled in an econometric success function: $W_i = \alpha + \beta X_i + \varepsilon_i$, where *i* catches the different individual riders' characteristics. In the next subsection we will first focus on the independent variables $X = x_1 + x_2 +,..., x_n$.

INDEPENDENT VARIABLES

We include several categories of independent variables: strength, experience, position in the team (team leader), physical condition and cultural background (country/region). This will allow to assume that the contestants are heterogeneous with different cost-of-effort functions.

It is highly important to take into consideration that athletes have different abilities to provide a strong test of an individual success model. Fortunately, our data set allows to include such proxies.

A) STRENGTH:

Previous performances might be a good proxy for the strength of an athlete. With the variable TOP20, we measure how many times a cyclist has been among the top 20 in *previous* Tours de France. It allows to see how well a rider has been able to perform in the past. The event requires specific skills and is not fully comparable to one-stage classics. Thus, it may be better to focus on past performances during the Tour de France with similar requirements over time, rather than working with world ranking systems such as the UCI that takes into account different kinds of races (PREDICTED SIGN: OLS: -, Ordered Probit: +, a better performance in previous years leads to a better classification in the present).

B) EXPERIENCES:

We will use proxies that measure the experience of a cyclist. First, we consider the number of years an athlete is professional, but instead of using it as a continuous variable, three classes have been formed: 0-5, 6-11-12-16, with 0-5 as reference group[3].

More experienced professionals are better aware of the possibilities and the dangers in a Tour covering several stages. This may help to optimize their performance. On the other hand, less experienced riders may be less restricted by previous professional experiences, more “hungry” to succeed, and in good physical condition. Thus, the impact of the different dummy variables is not clear (predicted sign OLS and Ordered Probit: +/-).

It may also be relevant to take into consideration previous experience at the Tour de France. Cyclists specialize in certain disciplines, and the number of years someone has been a professional may not go in line with the ability to perform in a Tour. Thus, having participated in a previous Tour de France proxied by the number of participations (NUMBERPART) may be more relevant than the years being a pro[4]. However, we expect a lower impact of EXPERIENCE compared to the STRENGTH variables. Specific Tour skills such as being a good all-rounder are essential to succeed. Athletes without such skills have a low chance of success even if they have participated several times. Furthermore, a Tour also allows to be specialized on winning stages rather than winning the Tour, as the competition also offers high (economic) incentives to win a stage (PREDICTED SIGNS: OLS: -, Ordered Probit: +, more experiences lead to a higher performance).

C) TEAM LEADER:

Strategizing influences a road race over several stages. Cycling tours are comparable to team sports such as football or soccer. Teams have clear hierarchical structures to allow the best athletes in a team to perform best in the Tour. Thus, team leaders profit from the help of other teammates. For example, they are more “protected” during the different stages. They are allowed to rest more in the bunch compared to the others who do the work, for example chasing down breaks or maintaining a high average speed in the mountains to distance the team leader’s rivals or just fetch the food. The team leader on the other hand is protected, riding in the main field or behind the other teammates saving lots of energy, which gives him a better chance to succeed.

The used data set has the advantage to provide the information who started as a team leader in the Tour de France 2004. This reduces possible causality problems based on individual performances during the race[5].

D) PHYSICAL PRECONDITION:

The physical preconditions of an athlete are deducted from his height and weight. As both variables are highly correlated (r=0.76), it may be relevant to build a factor that considers both determinants. One possibility is to calculate the body-mass index (BMI) that measures the height/weight ratio (weight in kilograms divided by the square of the height in meters). . Individuals with a lower BMI may have lower constraints to their performance in an endurance competition. However, this factor does not directly measure the endurance or muscle strength. As the information about height and weight is missing for 8 cyclists, we do not use the BMI in the first estimations (PREDICTED SIGN: OLS: +, Ordered Probit: -, a lower BMI leads to a better performance).

E) REGIONS:

It will be interesting to see whether there are regional differences among cyclists. We classified the riders based on the number of observations in single countries or in regions (see also Appendix *Table A1*). The race being held in France might have a positive influence on the success of a French cyclist. It can be assumed that a strong support by the audience, high outside expectations, being more in the public eye, cultural closeness, being used to perform in such geographic settings, and other home advantages will result in a better performance.

Thus, we will investigate whether a French cyclist (reference group), holding other factors constant, performs better than other athletes. Support for a positive home advantage has been observed in football. Torgler (2004a, 2004c), e.g., found that being a hosting nation in a World Cup has a significant impact on the performances in World Cup tournaments. However, national identity is less visible in the cycling circuit. As mentioned in Section II cyclists are working for commercially sponsored teams and not national teams. As the Tour de France routes are passing close to the neighboring countries or even cross the border, it will be interesting to observe how these cyclists perform (e.g., Spain, Germany, Italy, Switzerland, Belgium, Luxembourg). Spectators in these countries have lower costs to attend the event and to support national cyclists. For example, it can be supposed that stages in the Pyrenees attract many Spanish spectators and stages in the Alps many Swiss, Italian or German citizens. Furthermore, many of these countries have a strong cycling tradition, hosting other majors such as the *Giro d'Italia* and the *Vuelta a España*.

EMPIRICAL RESULTS

FINAL RANKING IN THE TOUR DE FRANCE

Table 1 and 2 present the empirical results of the first estimations, which investigate the final ranking as a dependent variable using OLS and ordered probit models. In Table 1, lower values go in line with a better individual performance. On the other hand, in Table 2, a higher ranking class is in line with a better performance. We present estimations with robust standard errors and corrected standard error values, clustered over the 21 teams that participated. Clustering allows to take into account team differences. In Table 1, we also estimate beta or standardized regression coefficients. This allows to compare the magnitude and thus helps to see the relative importance of the used variables. In the first two estimations, only the riders who finished the Tour de France are considered. In a second step, all the participants are included. In the OLS, the ranking has been adapted, taking into account in which stage a rider has given up. The earlier a rider gave up, the lower his output and thus the higher (worse) his final ranking. In the ordered probit estimations, all the riders who gave up the race were classified in the lowest ranking group (see Appendix Table A1).

The estimated coefficients are mostly consistent with the hypotheses. Good performances in previous Tours (TOP20) lead to a better performance in the present one. The coefficients in all estimations are highly statistically significant with *beta* values around -0.20.

Table 2 indicates that an increase in the top performances in previous Tours by one scale increases the probability to get into the top 25 positions by between 5.3 and 7.8 percentage points. On the other hand, it reduces the probability of giving up the Tour by 8 percentage points. In sum, these results show that good performances in the past are a good indicator for good performances in the present.

Being a team leader also increases the probability to reach the best 25 positions by 53 percentage points, if we consider those riders who finished the Tour. The beta value is among the largest. However, considering all participants the statistically significant impact is reduced[6]. For possible counter-effects it can be argued that team leaders who started with a real chance to win the Tour may have a higher incentive to give up if it does not work as expected (no real chance to win). Giving up in such a situation can be rational as it allows to reduce costs (possible wastes) that could affect the performance in future events (e.g., the Vuelta in September or the Olympics 2004 in August). Thus, there seemed to be a strategy among team leaders either to “win the mare or lose the halter”. Not less than 1/3 of all team leaders gave up the race before reaching the final stage in Paris.

A higher BMI value leads to a lower performance at the Tour de France. The coefficient is highly statistically significant. Thus, the physical condition of a rider is of relevance and helps to explain his performance. A decrease in the BMI-scale by one unit increases the probability of belonging to the top 25 final riders by more than 3 percentage points and decreases the probability of giving up by 5.3 percentage points.

Interestingly, there is the tendency that differences in experience matter. Younger cyclists (pro 0-5 years, reference group) perform better than the other two groups, especially in comparison with the oldest ones, showing a statistically significant difference in some estimations. On the other hand, the number of previous participations shows the tendency to better performances, with the strongest correlation in those estimations that consider only the riders who finished the Tour (controlling also for the BMI). In general, the results imply that being successful at the Tour requires specific abilities (e.g., good all-rounder). Thus, more experienced professionals have no general comparative advantage. Specific skills seemed to be more important for success than just experience, which allows young cyclists to perform at a high level.

Table 1 and 2 indicate that some countries/regions perform better than others. Italy, Spain, Germany, Belgium, Scandinavia, CEE and FSU, USA and riders in the group OTHERS perform better than the reference group (France). However, considering all riders and not just those who finished the race reduces statistically significant differences among the countries/regions (especially in the ordered probit estimations). Relatively robust findings can be observed for the nations USA, Spain, Germany and CEE & FSU countries. Being from the USA rather than from France increases a rider's probability of reaching a position among the top 25 riders by more than 20 percentage points and reduces the probability of giving up by around 16 percentage points. In general, the result contradicts previous findings in team sports such as football where the home advantage is highly relevant. This is however no real surprise as in the Tour the individual's and not the nation's success is important and honored.

TABLE 1: Determinants of Total Classification Success Using OLS Models

OLS	robust standard errors			standard errors adjusted for clust-ering on teams		robust standard errors			standard errors adjusted for clust-ering on teams		robust standard errors			standard errors adjusted for clust-ering on teams	
	Estimations with all the cyclists who finished the Tour de France										Estimations with all participants				
Dep. Var.: RANKING	**Coeff.**	**Beta**	**t**	**Coeff.**	**t**	**Coeff.**	**Beta**	**t**	**Coeff.**	**t**	**Coeff.**	**Beta**	**t**	**Coeff.**	**t**
a) STRENGTH															
TOP20	-7.513***	-0.226	-3.40	-7.513***	-3.76	-6.659***	-0.202	-3.27	-6.659***	-4.14	-9.696***	-0.230	-3.53	-9.696***	-5.28
b) EXPERIENCE															
PRO 6-11 YEARS	7.420	0.087	1.06	7.420	1.27	7.946	0.092	1.12	7.946	1.26	4.921	0.048	0.58	4.921	0.78
PRO 12-16 YEARS	26.459**	0.189	2.06	26.459**	2.60	33.783***	0.236	2.91	33.783***	3.32	20.166	0.119	1.26	20.166	1.22
NUMBERPART	-1.938	-0.135	-1.50	-1.938	-1.65	-2.456*	-0.169	-1.94	-2.456**	-2.21	-1.639	-0.093	-0.98	-1.639	-0.97
c) POSITION															
TEAM LEADER	-39.300***	-0.263	-3.64	-39.300***	-3.49	-39.006***	-0.263	-3.97	-39.006***	-3.78	-6.070	-0.038	-0.35	-6.070	-0.33
d) PHYSICAL PRECONDITIONS															
BMI						7.770***	0.211	3.37	7.770***	2.77	7.796***	0.189	2.91	7.796**	2.39
e) REGIONAL VARIABLES															
ITALY	-10.296	-0.080	-0.87	-10.296	-1.00	-13.403	-0.102	-1.16	-13.403	-1.13	5.454	0.040	0.44	5.454	0.43
SPAIN	-42.576***	-0.383	-4.55	-42.576***	-3.74	-40.661***	-0.356	-4.17	-40.661***	-3.32	-29.627**	-0.215	-2.41	-29.627*	-1.96
GERMANY	-28.682**	-0.185	-2.43	-28.682**	-2.19	-30.643***	-0.200	-2.75	-30.643**	-2.48	-23.233*	-0.127	-1.72	-23.233*	-1.79
NETHERLANDS	21.141**	0.106	2.09	21.141**	2.07	23.240**	0.118	2.16	23.240**	2.39	19.066*	0.077	1.70	19.066**	2.19
BELGIUM	-5.341	-0.027	-0.32	-5.341	-0.42	-7.071	-0.036	-0.46	-7.071	-0.54	-8.972	-0.036	-0.60	-8.972	-0.79
SCANDINAVIA	-5.676	-0.026	-0.31	-5.676	-0.31	-10.485	-0.049	-0.54	-10.485	-0.54	-2.851	-0.012	-0.15	-2.851	-0.16
CEE & FSU COUNTRIES	-25.508**	-0.158	-2.16	-25.508*	-1.84	-31.264***	-0.187	-2.68	-31.264**	-2.32	-16.685	-0.088	-1.13	-16.685	-1.27
SWITZERLAND AND AUSTRIA	11.688	0.062	1.08	11.688	1.04	8.621	0.041	0.71	8.621	0.70	18.752	0.081	1.22	18.752*	1.86
AUSTRALIA AND NEW ZEALAND	15.398	0.082	0.85	15.398	0.71	14.614	0.074	0.76	14.614	0.63	8.640	0.037	0.47	8.640	0.37
USA	-46.262***	-0.216	-4.99	-46.262***	-4.94	-56.421***	-0.266	-6.37	-56.421***	-5.31	-48.524**	-0.185	-2.17	-48.524*	-1.89
OTHERS	-24.176	-0.103	-1.41	-24.176	-1.35	-26.253	-0.113	-1.59	-26.253	-1.48	-32.762**	-0.106	-2.05	-32.762*	-1.96
Number of observations	147			147		139			139		180			180	
Prob > F	0.000			0.000		0.000			0.000		0.000			0.000	
R-squared	0.416			0.416		0.455			0.455		0.250			0.250	

NOTES: In the reference group is: PRO 0-5 YEARS, NOT A TEAM LEADER, FRANCE. RANKING: the higher the value, the lower the performance. Significance levels: * 0.05 < p < 0.10, ** 0.01< p < 0.05, *** p < 0.01.

TABLE 2: Determinants of Total Classification Success Using Ordered Probit Models

ORDERED PROBIT	robust standard errors			standard errors adjusted for clustering on teams			robust standard errors				standard errors adjusted for clustering on teams			
	Estimations with all the cyclists who finished the Tour						Estimations with all the participants							
Dep. Var.: RANKING	**Coeff.**	**z-Stat.**	**Marg. (5)**	**Coeff.**	**z-Stat.**	**Marg. (5)**	**Coeff.**	**z-Stat.**	**Marg. (1)**	**Marg. (5)**	**Coeff.**	**z-Stat.**	**Marg. (1)**	**Marg. (5)**
a) STRENGTH														
TOP20	0.413***	4.19	0.078	0.413***	3.78	0.078	0.290***	3.52	-0.080	0.053	0.290***	4.84	-0.080	0.053
b) EXPERIENCE														
PRO 6-11 YEARS	-0.327	-1.40	-0.063	-0.327*	-1.87	-0.063	-0.109	-0.57	0.030	-0.020	-0.109	-0.66	0.030	-0.020
PRO 12-16 YEARS	-1.244***	-2.87	-0.127	-1.244***	-3.68	-0.127	-0.418	-1.06	0.130	-0.062	-0.418	-1.03	0.130	-0.062
NUMBERPART	0.035	0.77	0.007	0.035	0.88	0.007	0.008	0.19	-0.002	0.001	0.008	0.20	-0.002	0.001
c) POSITION														
TEAM LEADER	1.667***	3.83	0.530	1.667***	3.48	0.530	0.089	0.21	-0.024	0.017	0.089	0.20	-0.024	0.017
d) PHYSICAL PRECONDITIONS														
BMI	-0.313***	-3.77	-0.059	-0.313***	-2.96	-0.059	-0.194***	-2.92	0.053	-0.036	-0.194**	-2.49	0.053	-0.036
e) REGIONAL VARIABLES														
ITALY	0.503	1.40	0.118	0.503	1.41	0.118	-0.230	-0.79	0.067	-0.038	-0.230	-0.93	0.067	-0.038
SPAIN	1.035***	3.22	0.277	1.035**	2.44	0.277	0.352	1.28	-0.087	0.074	0.352	0.93	-0.087	0.074
GERMANY	0.726**	2.01	0.189	0.726	1.59	0.189	0.190	0.64	-0.049	0.038	0.190	0.67	-0.049	0.038
NETHERLANDS	-0.518	-1.15	-0.073	-0.518	-1.52	-0.073	-0.284	-0.94	0.087	-0.044	-0.284	-1.33	0.087	-0.044
BELGIUM	0.607	1.06	0.154	0.607	1.22	0.154	0.365	1.04	-0.086	0.081	0.365	1.49	-0.086	0.081
SCANDINAVIA	0.242	0.36	0.052	0.242	0.34	0.052	-0.055	-0.13	0.016	-0.010	-0.055	-0.13	0.016	-0.010
CEE & FSU	1.023***	3.06	0.295	1.023***	2.69	0.295	0.206	0.62	-0.052	0.042	0.206	0.80	-0.052	0.042
SWITZERLAND AND AUSTRIA	-0.438	-0.93	-0.064	-0.438	-1.00	-0.064	-0.528	-1.34	0.172	-0.071	-0.528**	-2.09	0.172	-0.071
AUSTRALIA/NEW ZEALAND	-0.725	-0.91	-0.090	-0.725	-0.82	-0.090	-0.148	-0.37	0.043	-0.025	-0.148	-0.33	0.043	-0.025
USA	1.771***	4.37	0.585	1.771***	3.91	0.585	0.898	1.55	-0.162	0.250	0.898	1.34	-0.162	0.250
OTHERS	0.541	1.11	0.135	0.541	1.02	0.135	0.461	1.30	-0.103	0.108	0.461	1.25	-0.103	0.108
Number of observations	139			139			180				180			
Prob > chi2	0.000			0.000			0.013				0.013			
Pseudo-squared	0.220			0.220			0.073				0.073			

NOTES: In the reference group is: PRO 0-5 YEARS, NOT A TEAM LEADER, FRANCE. RANKING: From 1-5 (5= ranking 1-25, the higher the value, the better the performance). Significance levels: * 0.05 < p < 0.10, ** 0.01< p < 0.05, *** p < 0.01. Marg. (5) = Marginal effect ranking index 5; Marg. (1)= Marginal effect ranking index 1 (not finished the competition).

PERFORMANCE IN THE TIME TRIALS AND THE MOUNTAINS

In the next two subsections we investigate different components of the Tour de France. We find that a good performance in the first time trial tends to be repeated in the second time trial, and that good results in the time trials are in line with good performances in the mountains. Table 3 also shows that there is a strong correlation between the final ranking and the performances in the time trials and the mountains. Thus, it may be interesting to investigate also what shapes individuals' performances in the time trials and the mountains.

TABLE 3: Performance Correlations

		FINAL RANKING	TIME TRIAL ONE	TIME TRIAL TWO	PROLOGUE	RANKING MOUNTAINS
FINAL RANKING	Pearson Correlation	1	0.854	0.816	0.226	0.635
	Sig. (2-tailed)	.	0.000	0.000	0.002	0.000
	N	188	188	188	188	188
TIME TRIAL ONE	Pearson Correlation	0.854	1	0.733	0.260	0.604
	Sig. (2-tailed)	0.000	.	.000	0.000	0.000
	N	188	188	188	188	188
TIME TRIAL TWO	Pearson Correlation	0.816	0.733	1	0.422	0.506
	Sig. (2-tailed)	0.000	0.000	.	0.000	0.000
	N	188	188	188	188	188
PROLOGUE	Pearson Correlation	0.226	0.260	0.422	1	0.159
	Sig. (2-tailed)	0.002	0.000	0.000	.	0.029
	N	188	188	188	188	188
RANKING MOUNTAINS	Pearson Correlation	0.635	0.604	0.506	0.159	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.029	.
	N	188	188	188	188	188

1. TIME TRIALS

All three individual time trials held at the Tour de France 2004 are analyzed empirically. A prologue on the first day (6.1 km in Liège), an individual time trial in the mountains (stage 16, 15.5 km, from Bourg d'Oisans (720m) to L'Alpe d'Huez (1850m)) and finally a time trial in stage 19 (55 km, in Besançon). A time trial allows to perform individually without the team. It is a race against the clock that helps to distance other cyclists. In the prologue, riders started in a time interval of one minute, following the order set by the race organizers and the team managers. In Bourg d'Oisans, most of the cyclists started at a 1 minute interval, the last ones at a 2 minute interval, the starting order being the reverse of the general ranking established in stage 15. Finally, in Besançon cyclists had a 2-minute interval (3 minutes for the last starters), starting also in the reverse order of the ranking at the end of stage 18. Table 3 indicates that the time trial one has the strongest correlation with the final performance. This mountain time trial, with a 13.8 km ascent (7.9 % inclination) covering 1130m of altitude (www.letour.com) attracted more than a million spectators, as previously mentioned. The time trial one also explains around 73 percent of the total variance of the final ranking position[7].

Table 4 and 5 present the results. In general, the results obtained using the performance of the time trial one as dependent variable are in line with the final ranking. Strong performances in previous Tours correlates with a strong performance in the time trial. The marginal effects are lower compared to the final classification, but the quantitative effects with marginal effects of 2.8 percentage points cannot be disregarded. The impact decreases in time trial two to 3.4 percentage points, which is on the border of significance, and gets statistically insignificant in the prologue.

Youngsters (0-5 years pro) also perform better than the other professional riders (especially those who have been professionals for more than 11 years). Being in this category rather than in the reference group reduces the probability of reaching a position among the top 25 by 9.2 percentage points. Similarly, the differences between the groups decrease in the time trial two and especially in the prologue. Being a team leader increases the probability of being classified in the top 25 in the mountain trial by not less than 34 percentage points. Such high marginal effects are obtained in all time trials (15.9 percentage points in the prologue and 36.7 percentage points in time trial two). The beta coefficients also indicate a strong relative impact of the variable TEAM LEADER. Thus, team leaders perform very strongly in the stages in which they act independently. This might partly be due to their protected role in the other stages, which allows them to save energy and thus perform better in the time trials.

Interestingly, only in the mountain time trials a high BMI value has a statistically significant negative impact on the performance. An increase in the index by one point reduces the probability of a top 25 classification by 5.3 percentage points. Thus, the physical precondition is highly relevant in the mountain time trial. We would also predict that a lower BMI should affect the total performance in the mountains.

Previous experiences at the Tour de France only matter in time trial two (longest one, classic time trial profile). An increase in participation by one unit raises the probability of reaching the top 25 positions by 2.3 percentage points.

TABLE 4: Determinants of Time Trial Performances Using OLS Models

OLS	robust standard errors			Clustering on teams		robust standard errors			Clustering on teams		robust standard errors			Clustering on teams	
	Time trial 1 (stage 16, 15.5 km)					Time trial 2 (stage 19, 55 km)					Prologue (6.1 km)				
Dep. Var.: RANKING	**Coeff.**	**Beta**	**t**	**Coeff.**	**t**	**Coeff.**	**Beta**	**t**	**Coeff.**	**t**	**Coeff.**	**Beta**	**t**	**Coeff.**	**t**
a) STRENGTH															
TOP20	-5.012**	-0.144	-2.17	-5.012***	-3.29	-3.595*	-0.108	-1.69	-3.951*	-1.93	3.657	0.081	0.89	3.657	1.08
b) EXPERIENCE															
PRO 6-11 YEARS	9.527	0.106	1.26	9.527	1.65	5.009	0.057	0.59	5.616	0.77	15.935*	0.146	1.72	15.935	1.65
PRO 12-16 YEARS	25.922**	0.175	2.10	25.922***	2.95	20.896	0.142	1.41	23.833	1.58	8.584	0.047	0.44	8.584	0.41
NUMBERPART	-2.045	-0.134	-1.59	-2.045	-1.65	-2.424	-0.164	-1.51	-2.405	-1.31	-2.208	-0.116	-0.97	-2.208	-0.90
c) POSITION															
TEAM LEADER	-35.219***	-0.230	-2.98	-35.219***	-3.14	-22.042	-0.150	-1.53	-23.808	-1.45	-37.783***	-0.218	-3.28	-37.783***	-2.88
d) PHYSICAL PRECONDITIONS															
BMI	9.223***	0.242	3.65	9.223***	3.19	0.902	0.024	0.30	1.487	0.48	-4.182	-0.095	-1.22	-4.182	-1.10
e) REGIONAL VARIABLES															
ITALY	-12.940	-0.099	-1.06	-12.940	-1.27	-5.398	-0.041	-0.44	-3.244	-0.32	1.331	0.009	0.11	1.331	0.12
SPAIN	-41.539***	-0.347	-3.84	-41.539***	-3.06	-32.975**	-0.287	-2.63	-34.903***	-3.68	-40.993***	-0.277	-3.04	-40.993***	-3.71
GERMANY	-24.287**	-0.153	-2.17	-24.287**	-2.01	-45.838***	-0.302	-3.40	-48.575***	-3.94	-58.805***	-0.299	-4.36	-58.805***	-5.70
NETHERLANDS	14.879*	0.070	1.73	14.879	1.71	-7.279	-0.036	-0.42	-9.869	-0.83	-7.288	-0.028	-0.37	-7.288	-0.34
BELGIUM	-12.467	-0.059	-0.97	-12.467	-1.09	-23.547	-0.117	-1.47	-26.864**	-2.08	-10.849	-0.041	-0.49	-10.849	-0.47
SCANDINAVIA	9.186	0.040	0.58	9.186	0.52	-21.696*	-0.100	-1.87	-24.363**	-2.00	-28.618	-0.108	-1.38	-28.618	-1.41
CEE & FSU COUNTRIES	-22.020	-0.129	-1.64	-22.020	-1.40	-37.896***	-0.232	-2.69	-40.816**	-2.58	-31.613**	-0.156	-2.11	-31.613**	-2.21
SWITZERLAND AND AUSTRIA	-2.419	-0.011	-0.14	-2.419	-0.16	-6.844	-0.031	-0.35	-9.044	-0.48	-7.272	-0.029	-0.38	-7.272	-0.35
AUSTRALIA AND NEW ZEALAND	19.401	0.092	0.86	19.401	0.77	4.461	0.021	0.28	5.935	0.38	-1.410	-0.006	-0.08	-1.410	-0.11
USA	-52.844***	-0.233	-5.10	-52.844***	-4.21	-79.773***	-0.367	-8.18	-82.686***	-9.82	-76.892***	-0.273	-5.31	-76.892***	-4.90
OTHERS	-54.901***	-0.221	-4.24	-54.901***	-3.91	-39.676**	-0.167	-2.13	-41.975**	-2.22	-43.106**	-0.130	-2.10	-43.106*	-1.97
Number of observations	147			147		140			140		180			180	
Prob > F	0.000			0.000		0.000			0.000		0.000			0.000	
R-squared	0.408			0.408		0.284			0.284		0.255			0.255	

NOTES: In the reference group is: PRO 0-5 YEARS, NOT A TEAM LEADER, FRANCE. RANKING: the higher the value, the lower the performance. Significance levels: * 0.05 < p < 0.10, ** 0.01< p < 0.05, *** p < 0.01.

Table 5: Determinants of Time Trial Performances Using Ordered Probit Models

ORDERED PROBIT	robust standard errors			Clustering on teams			robust standard errors			Clustering on teams			robust standard errors			Clustering on teams		
	Time trial 1 (stage 16, 15.5 km)						Time trial 2 (stage 19, 55 km)						Prologue (6.1 km)					
Dep. Var.: RANKING	**Coeff.**	**z-Stat.**	**Marg.**	**Coeff.**	**z-Stat.**	**Marg.**	**Coeff.**	**z-Stat.**	**Marg.**	**Coeff.**	**z-Stat.**	**Marg.**	**Coeff.**	**z-Stat.**	**Marg.**	**Coeff.**	**z-Stat.**	**Marg.**
a) STRENGTH																		
TOP20	0.161**	1.99	0.028	0.161**	2.48	0.028	0.126*	1.76	0.034	0.126	1.65	0.034	-0.030	-0.36	-0.006	-0.030	-0.36	-0.006
b) EXPERIENCE																		
PRO 6-11 YEARS	-0.300	-1.27	-0.054	-0.300	-1.37	-0.054	-0.084	-0.36	-0.023	-0.084	-0.39	-0.023	-0.278	-1.29	-0.052	-0.278	-1.14	-0.052
PRO 12-16 YEARS	-0.786**	-2.13	-0.092	-0.786***	-2.60	-0.092	-0.800*	-1.73	-0.156	-0.800	-1.57	-0.156	-0.061	-0.15	-0.011	-0.061	-0.14	-0.011
NUMBERPART	0.049	1.29	0.009	0.049	1.32	0.009	0.084*	1.77	0.023	0.084*	1.90	0.023	0.062	1.25	0.011	0.062	1.27	0.011
c) POSITION																		
TEAM LEADER	1.215***	2.72	0.347	1.215***	2.70	0.347	1.058***	2.91	0.367	1.058***	2.99	0.367	0.653***	2.59	0.159	0.653***	2.54	0.159
d) PHYSICAL PRECONDITIONS																		
BMI	-0.300***	-3.49	-0.053	-0.300***	-2.89	-0.053	-0.035	-0.41	-0.010	-0.035	-0.41	-0.010	0.020	0.26	0.004	0.020	0.26	0.004
e) REGIONAL VARIABLES																		
ITALY	0.385	1.10	0.080	0.385	1.18	0.080	0.264	0.90	0.077	0.264	1.04	0.077	0.008	0.03	0.001	0.008	0.03	0.001
SPAIN	1.165***	3.32	0.307	1.165***	3.06	0.307	1.146***	3.42	0.386	1.146***	4.42	0.386	0.926***	3.09	0.238	0.926***	3.73	0.238
GERMANY	0.629*	1.78	0.149	0.629*	1.66	0.149	1.553***	5.24	0.549	1.553***	5.85	0.549	1.303***	3.58	0.391	1.303***	5.03	0.391
NETHERLANDS	-0.386	-1.22	-0.054	-0.386	-1.52	-0.054	0.298	0.61	0.089	0.298	1.08	0.089	0.196	0.53	0.040	0.196	0.63	0.040
BELGIUM	0.400	0.83	0.087	0.400	1.22	0.087	0.602	1.24	0.197	0.602	1.52	0.197	0.268	0.55	0.057	0.268	0.45	0.057
SCANDINAVIA	-0.658	-0.94	-0.077	-0.658	-0.87	-0.077	0.725**	2.40	0.244	0.725**	2.25	0.244	0.884**	2.08	0.244	0.884**	2.52	0.244
CEE & FSU COUNTRIES	0.687*	1.82	0.168	0.687	1.62	0.168	1.355***	4.24	0.482	1.355***	4.81	0.482	0.811**	2.56	0.214	0.811***	2.90	0.214
SWITZERLAND AND AUSTRIA	0.270	0.62	0.055	0.270	0.72	0.055	0.185	0.24	0.053	0.185	0.24	0.053	0.082	0.16	0.016	0.082	0.13	0.016
AUSTRALIA AND NEW ZEALAND	-0.387	-0.51	-0.054	-0.387	-0.47	-0.054	-0.628	-0.91	-0.127	-0.628	-0.89	-0.127	0.240	0.62	0.050	0.240	0.82	0.050
USA	1.410***	3.31	0.438	1.410***	2.98	0.438	9.885***	27.20	0.905	9.885***	23.68	0.905	2.479***	4.08	0.782	2.479***	3.56	0.782
OTHERS	1.448***	3.63	0.455	1.448***	3.44	0.455	1.125**	2.02	0.402	1.125**	2.03	0.402	0.876**	2.36	0.244	0.876**	2.20	0.244
Number of observations	147			147			139			139			180			180		
Prob > chi2	0.000			0.000			0.000			0.000			0.000			0.000		
Pseudo-squared	0.156			0.156			0.158			0.158			0.100			0.100		

Notes: In the reference group is: NOT IN THE TOP20 IN PREVIOUS YEARS, PRO 0-5 YEARS, NOT A TEAM LEADER, FRANCE. RANKING: From 1-5 (5= ranking 1-25, the higher the value, the better the performance). Significance levels: * $0.05 < p < 0.10$, ** $0.01 < p < 0.05$, *** $p < 0.01$. Marg.= Marginal effect ranking index 5.

Regional differences also matter in the time trials. Being a Spanish rather than a French rider increases the probability of being classified in the top 25 positions between 23.8 and 38.6 percentage points. American riders perform particularly very well in the time trials, with marginal effects between 43.8 and 90.5 percentage points. Strong performances are also observed for German, CEE/FSU riders and those in the group OTHERS.

2. PERFORMANCE IN THE MOUNTAINS

The most difficult parts in the Tour are the mountains, as they require high efforts. They allow individuals to distance themselves from others. A bad day or a moment of weakness in the mountains has a different magnitude of importance than in other stages. It can be decisive for being successful at the Tour. Table 3 indicates a strong correlation between the performance in the mountains and the final ranking (lower as in the time trials one and two, but with 0.635 still very high). As a proxy we use the ranking in the climber classification. At each summit of a hill or each pass points are attributed. The higher the category of the ascent, the more points for crossing first the line at the top of the mountain. The general classification is calculated by adding all points together. Only 69 cyclists were able to obtain points in the mountains. To maintain the number of observations in the estimations, all other riders have been placed at the ranking position 70 in the OLS estimations and in the lowest category in the ordered probit estimations (see Table A1 in the Appendix).

Tables 6 and 7 present the results. In line with our expectations, a lower BMI leads to a better performance in the mountains. While Table 6 indicates the largest beta coefficients, Table 7 shows that one unit increase in the BMI reduces the probability of belonging to the top 25 climbers by more than 3 percentage points. Team leaders also perform better in the mountains. On the other hand, the coefficient TOP20 shows the lowest performance impact across all the different dependent variables, being only statistically significant in 3 out of 8 estimations. There is also the tendency of a better performance of the youngsters compared to the other riders. However, the difference is statistically significant in one estimation only. It is also interesting to observe that regional differences are less obvious in the mountains than in the final ranking and the time trials. There is the tendency that Spanish and USA riders perform better than the French cyclists, but the coefficient is not statistically significant in all estimations. On the other hand, riders from AUSTRALIA and NEW ZEALAND have more difficulties to perform in the mountains compared to the reference group; this result is statistically significant in 6 out of 8 estimations.

TABLE 6: Determinants of Mountain Performances Using OLS Models

OLS	robust standard errors			standard errors adjusted for clustering on teams		robust standard errors			standard errors adjusted for clustering on teams	
	Estimations with all the cyclists who finished the Tour					Estimations with all the originally participating cyclists				
Dep. Var.: RANKING	**Coeff.**	**Beta**	**t**	**Coeff.**	**t**	**Coeff.**	**Beta**	**t**	**Coeff.**	**t**
a) STRENGTH										
TOP20	-2.028	-0.118	-1.45	-2.028	-1.32	-3.228**	-0.185	-2.12	-3.228**	-2.12
b) EXPERIENCE										
PRO 6-11 YEARS	3.142	0.070	0.83	3.142	1.23	3.031	0.072	0.91	3.031	1.34
PRO 12-16 YEARS	7.248	0.097	0.90	7.248	1.15	6.543	0.094	0.95	6.543	1.07
NUMBERPART	-0.188	-0.025	-0.23	-0.188	-0.39	-0.301	-0.041	-0.45	-0.301	-0.62
c) POSITION										
TEAM LEADER	-32.109***	-0.416	-5.28	-32.109***	-5.26	-16.242**	-0.243	-2.32	-16.242**	-2.15
d) PHYSICAL PRECONDITIONS										
BMI	3.824**	0.200	2.57	3.824*	1.84	3.212**	0.188	2.54	3.212*	1.99
e) REGIONAL VARIABLES										
ITALY	-9.044	-0.132	-1.63	-9.044**	-2.52	-2.321	-0.041	-0.49	-2.321	-0.79
SPAIN	-8.778*	-0.148	-1.75	-8.778*	-1.81	-4.597	-0.081	-0.94	-4.597	-0.76
GERMANY	-11.130	-0.139	-1.46	-11.130	-1.39	-8.400	-0.111	-1.25	-8.400	-1.15
NETHERLANDS	-0.365	-0.004	-0.05	-0.365	-0.08	0.778	0.008	0.12	0.778	0.18
BELGIUM	-3.010	-0.029	-0.35	-3.010	-0.44	-3.434	-0.034	-0.47	-3.434	-0.59
SCANDINAVIA	-3.216	-0.029	-0.28	-3.216	-0.27	0.542	0.005	0.06	0.542	0.06
CEE & FSU	0.122	0.001	0.02	0.122	0.02	1.268	0.016	0.26	1.268	0.31
SWITZERLAND AND AUSTRIA	-0.940	-0.009	-0.14	-0.940	-0.15	2.148	0.022	0.39	2.148	0.59
AUSTRALIA/NEW ZEALAND	15.054**	0.147	2.49	15.054**	2.29	11.214***	0.116	2.63	11.214***	2.82
USA	-18.780*	-0.170	-1.77	-18.780	-1.36	-14.493	-0.134	-1.27	-14.493	-0.98
OTHERS	-3.695	-0.031	-0.34	-3.695	-0.34	-3.541	-0.028	-0.34	-3.541	-0.34
Number of observations	139			139		180			180	
Prob > F	0.000			0.000		0.001			0.001	
R-squared	0.360			0.360		0.233			0.233	

NOTES: In the reference group is: NOT IN THE TOP20 IN PREVIOUS YEARS, PRO 0-5 YEARS, NOT A TEAM LEADER, FRANCE. RANKING: the higher the value, the lower the performance. Significance levels: * $0.05 < p < 0.10$, ** $0.01 < p < 0.05$, *** $p < 0.01$.

TABLE 7: Determinants of Mountain Performances Using Ordered Probit Models

ORDERED PROBIT	robust standard errors			standard errors adjusted for clustering on teams			robust standard errors			standard errors adjusted for clustering on teams		
	Estimations with all the cyclists who finished the Tour						Estimations with all the originally participated cyclists					
Dep. Var.: RANKING	**Coeff.**	**z-Stat.**	**Marg.**	**Coeff.**	**z-Stat.**	**Marg.**	**Coeff.**	**z-Stat.**	**Marg.**	**Coeff.**	**z-Stat.**	**Marg.**
a) STRENGHT												
TOP20	0.105	1.07	0.023	0.105	1.11	0.023	0.144	1.60	0.027	0.144*	1.73	0.027
b) EXPERIENCE												
PRO 6-11 YEARS	-0.318	-1.32	-0.070	-0.318*	-1.67	-0.070	-0.282	-1.30	-0.053	-0.282	-1.60	-0.053
PRO 12-16 YEARS	-0.791	-1.51	-0.118	-0.791*	-1.89	-0.118	-0.630	-1.39	-0.084	-0.630	-1.61	-0.084
NUMBERPART	0.042	0.76	0.009	0.042	1.21	0.009	0.038	0.78	0.007	0.038	1.06	0.007
c) POSITION												
TEAM LEADER	1.608***	4.11	0.533	1.608***	4.31	0.533	0.658*	1.75	0.161	0.658	1.58	0.161
d) PHYSICAL PRECONDITIONS												
BMI	-0.205**	-2.16	-0.044	-0.205	-1.64	-0.044	-0.189**	-2.26	-0.035	-0.189*	-1.77	-0.035
e) REGIONAL VARIABLES												
ITALY	0.458	1.19	0.118	0.458*	1.76	0.118	0.015	0.04	0.003	0.015	0.08	0.003
SPAIN	0.521*	1.79	0.134	0.521*	1.90	0.134	0.318	1.15	0.067	0.318	1.06	0.067
GERMANY	0.446	0.96	0.116	0.446	0.91	0.116	0.265	0.65	0.056	0.265	0.62	0.056
NETHERLANDS	0.185	0.42	0.044	0.185	0.49	0.044	0.135	0.33	0.027	0.135	0.35	0.027
BELGIUM	-0.011	-0.02	-0.002	-0.011	-0.02	-0.002	-0.001	0.00	0.000	-0.001	0.00	0.000
SCANDINAVIA	-0.236	-0.30	-0.045	-0.236	-0.30	-0.045	-0.408	-0.58	-0.059	-0.408	-0.54	-0.059
CEE & FSU	-0.332	-0.61	-0.061	-0.332	-0.59	-0.061	-0.454	-0.94	-0.065	-0.454	-1.13	-0.065
SWITZERLAND AND AUSTRIA	0.035	0.08	0.008	0.035	0.09	0.008	-0.204	-0.50	-0.034	-0.204	-0.73	-0.034
AUSTRALIA/NEW ZEALAND	-1.300*	-1.77	-0.139	-1.300	-1.53	-0.139	-0.991*	-1.75	-0.102	-0.991	-1.50	-0.102
USA	0.901*	1.65	0.278	0.901	1.33	0.278	0.759	1.47	0.202	0.759	1.20	0.202
OTHERS	0.141	0.22	0.033	0.141	0.22	0.033	0.186	0.31	0.038	0.186	0.31	0.038
Number of observations	139			139			180			180		
Prob > chi2	0.000			0.000			0.038			0.038		
Pseudo-squared	0.133			0.133			0.090			0.090		

NOTES: In the reference group is: PRO 0-5 YEARS, NOT A TEAM LEADER, FRANCE. RANKING: From 1-4 (4= ranking 1-25, the higher the value, the better the performance). Significance levels: * 0.05 < p < 0.10, ** 0.01< p < 0.05, *** p < 0.01. Marg.= Marginal effect ranking index 4.

4. TEAM EFFECTS ON THE FINAL RANKING IN THE TOUR DE FRANCE

Teamwork has been intensively analyzed in labor economics. Teamwork is desirable, as it allows to realize gains from complementarities in the production and facilitates gains from specialization by accumulating task-specific human capital, which may be valuable to other team members (see Lazear, 1998). Hamilton, Nickerson & Owan (2003) find that the composition of the team has a strong impact on its productivity. However, empirical studies are still rare, due to the difficulties to obtain data (see Idson & Kahane, 2000). Our data set allows to investigate the impact of team colleagues on riders' performance. Idson & Kahane

(2000) developed an interesting approach to investigate empirically the impact of coworkers on individual productivity and on salary determination in the National Hockey League. They develop a proxy that measures the quality of players around any individual player *i*. They calculate the average performances per game for the team as a whole excluding the individual player *i*'s performance contribution. Thus, in line with this approach we develop the teammates' strength (TEAM TOP20) and experiences (TEAM PRO YEARS[8], SQ TEAM PRO YEARS[9], TEAM NUMBERPART). As the dependent variable we use the final ranking estimating OLS and ordered probit estimations. Furthermore, corrected standard error values clustering on teams allow to take into account possible unobservable team specific characteristics.

Table 8 presents the results. Including team variables that measure the averages in strength and experiences has no impact on our previous findings. The coefficients TOP20, TEAM LEADER and BMI are still highly statistically significant with the tendency of a slight decline in the marginal effects. On the other hand the coefficient of TEAM TOP20 is not statistically significant. This result suggests that there is a low correlation between teammates' top performances in the past and the riders' current performance. On the other hand, teammate experiences show some interesting implications. Teammates' professional years have a non-linear impact on a rider's individual performances. We find a U-shaped curve. A higher average of younger and elder teammates leads to a better individual performance. However, this result is only statistically significant in those estimations considering the riders who reached Paris. A rider in a team with more experienced Tour de France teammates also performs better ceteris paribus; this finding is statistically significant in the estimations with all participating riders. An increase in the experience scale by one unit increases the probability of getting into the top25 positions by 3.9 percentage points and reduces the chance to give up by 6.1 percentage points. In general, the team variables are jointly significant in all estimations at the 1% or 5% percent level. The results suggest that the riders' performance in the Tour de France is influenced by other teammates. These findings are in line with the study by Idson & Kahane (2000).

TABLE 8: Team Effects on Riders' Total Performance

ORDERED PROBIT (standard error clustering on teams)	OLS		Ordered Probit			OLS		Ordered Probit			
	Estimations with all the cyclists who finished the Tour					Estimations with all the originally participating cyclists					
Dep. Var.: RANKING	**Coeff.**	**t-Stat.**	**Coeff.**	**z-Stat.**	**Marg. Outc. 5**	**Coeff.**	**t-Stat.**	**Coeff.**	**z-Stat.**	**Marg. Outc. 1**	**Marg. Outc. 5**
a) STRENGTH											
TOP20	-6.442***	-3.16	0.407***	3.06	0.070	-7.482***	-3.63	0.235***	3.43	-0.063	0.040
b) EXPERIENCE											
NUMBERPART	8.336	1.45	-0.353**	-2.04	-0.062	2.726	0.43	-0.052	-0.31	0.014	-0.009
PRO 6-11 YEARS	35.993***	3.07	-1.368***	-3.41	-0.118	21.839	1.39	-0.469	-1.20	0.145	-0.063
PRO 12-16 YEARS	-2.202	-1.65	0.036	0.74	0.006	-1.016	-0.66	-0.005	-0.14	0.001	-0.001
c) POSITION											
TEAM LEADER	-38.242***	-3.80	1.613***	2.80	0.492	-15.639	-0.85	0.354	0.75	-0.083	0.072
d) PHYSICAL PRECOND.											
BMI	6.839**	2.48	-0.287**	-2.55	-0.050	7.028**	2.02	-0.180**	-2.12	0.048	-0.031
e) REGIONAL VARIABLES											
ITALY	-11.724	-1.09	0.529	1.39	0.116	6.213	0.53	-0.239	-0.86	0.069	-0.037
SPAIN	-40.905***	-3.40	1.176***	2.72	0.306	-30.562**	-2.16	0.430	1.16	-0.100	0.088
GERMANY	-27.057**	-2.31	0.775*	1.76	0.192	-16.018	-1.48	0.087	0.39	-0.023	0.016
NETHERLANDS	23.809**	2.33	-0.569	-1.54	-0.069	31.686***	3.17	-0.659***	-3.24	0.218	-0.075
BELGIUM	-7.915	-0.43	0.647	0.99	0.156	-2.341	-0.15	0.170	0.50	-0.042	0.032
SCANDINAVIA	-5.147	-0.23	0.135	0.16	0.025	8.474	0.38	-0.315	-0.56	0.095	-0.045
CEE & FSU	-33.347**	-2.20	1.216***	2.66	0.350	-15.347	-1.07	0.202	0.64	-0.050	0.039
SWITZERLAND/AUSTRIA	7.338	0.63	-0.340	-0.71	-0.048	14.492	1.30	-0.439	-1.59	0.137	-0.058
AUSTRALIA/NZL	15.115	0.72	-0.712	-0.78	-0.079	20.570	0.85	-0.466	-0.95	0.147	-0.060
USA	-54.614***	-4.60	1.899***	4.47	0.615	-38.965	-1.60	0.723	1.12	-0.137	0.181
OTHERS	-18.338	-1.05	0.363	0.72	0.077	-24.797	-1.62	0.321	0.93	-0.074	0.066
f) TEAM EFFECTS											
TEAM TOP20	-2.241	-0.23	-0.125	-0.29	-0.022	-4.921	-0.62	0.024	0.11	-0.006	0.004
TEAM PRO YEARS	57.500***	2.80	-1.787**	-2.45	-0.308	6.156	0.27	0.083	0.15	-0.022	0.014
SQ TEAM PRO YEARS	-4.040***	-2.93	0.125***	2.61	0.022	-0.512	-0.34	-0.004	-0.10	0.001	-0.001
TEAM NUMBERPART	-3.894	-1.06	0.178	1.14	0.031	-8.026**	-2.30	0.229**	2.45	-0.061	0.039
Number of observations	139		139			180		180			
R-squared	0.505					0.299					
Pseudo-squared			0.245					0.095			

NOTES: In the reference group is: PRO 0-5 YEARS, NOT A TEAM LEADER, FRANCE. RANKING OLS: the higher the value, the lower the performance. Ordered Probit: from 1-5 (5= ranking 1-25, the higher the value, the better the performance). Significance levels: * $0.05 < p < 0.10$, ** $0.01 < p < 0.05$, *** $p < 0.01$.

CONCLUSIONS

In recent years, we have been observing a strong expansion of economics to ‘non-market topics’. *Sportometrics*, a sub-field in this area, is a promising line of research for the future. Sport events are comparable to field experiments. They take place in a controlled environment evoking actual and real processes based, e.g., on high economic incentives. Many papers have analyzed sports such as soccer, football, baseball, basketball, or golf. This paper focuses on cycling and reports empirical evidence of individuals’ performances in the Tour de France using several dependent variables. All measure cyclist’s output (success) in different categories at the Tour de France 2004 such as total ranking, mountain ranking and the time trials rankings. Using the ranking instead of the time difference as dependent variable is relevant, because many incentives such as the prize money are connected to the rank. To check the robustness of the results we present ordered probit and OLS estimations.

Contrary to many other previous papers on sport, we take into account that cyclists are heterogeneous, i.e. they have different abilities and physical conditions. We include therefore several categories of independent variables: strength, experience, position in the team (team leader), physical condition and cultural background (country/region).

The results indicate that top performances in previous Tour de France events lead to a better performance in the present and reduce the probability of giving up the race. Historical top final performances are also correlated with a strong performance in the time trials, but not consistently with the performance in the mountains. Being a team leader also increases the probability to reach the best 25 positions. However, considering all the riders who participated reduces the impact. Not less than 1/3 of all team leaders gave up the race before reaching the final stage in Paris, which indicates that team leaders act to “win the mare or lose the halter”. Physical conditions have a strong impact on riders’ performances. A higher BMI value is connected with a lower final ranking at the Tour de France. It increases the probability of giving up. The BMI is also highly relevant for the mountain time trial and the mountains, but has no impact on the performance in the regular time trial and the prologue. We also observed a strong performance of the youngsters, especially compared to the older riders. The results imply that being successful at the Tour requires specific abilities (e.g., good all-rounder). Thus, more experienced professionals have no general comparative advantage. Specific skills seemed to be more important for success than just experience, which allows young riders to perform at a high level. We also found that some countries/regions perform better than others. Taking into consideration all the dependent variables, cyclists from USA, Spain, Germany, CEE/FSU, and those in the group OTHERS perform better than the reference group (France). The differences between nationals/regions are the smallest in the mountain performances.

The literature lacks empirical evidence on team effects. This paper thus contributes to the literature exploring the impact of teammates on a rider's individual performance, controlling for the separate effect of his own personal conditions. The results suggest, in line with previous empirical findings in the National Hockey League, that individuals' performances are influenced by the teammates.

This paper can be seen as a first attempt to investigate a cycling event such as the Tour de France. It might be interesting to carry on research and thus get more insights into the economics of a cycling tour. Future research could include more than one Tour de France or focus on other tours such as the *Giro* or the *Vuelta*. This would help to get more insights and to check the robustness of our reported findings. Another promising area would be to take a closer view to what happens during the *whole* tour in time series analysis. A more dynamic approach should give additional insights. In line with this, there is the possibility to investigate empirically more than one Tour de France event or observe riders' career performances over time. Finally, it may also be interesting to analyze with historical data to which extent success depends on the improvement of technological or human skills .

Without any doubt, *the economics of cycling* has a future and will allow to investigate many interesting topics.

REFERENCES

Allison, P. D. (1999). *Multiple Regression: A Primer*. California: The Pine Forge Press.

Bernard, A. B. & Busse, M. R. (2004). Who Wins the Olympic Games: Economic Resources and Medal Totals. *Review of Economics and Statistics*, 86, 413-417.

Burdekin, R. C. K. & Idson, T. L. (1991). Customer Preferences, Attendance and Racial Structure of Professional Basketball Teams. *Applied Economics*, 23, 179-186.

Burtless, G. (1995). The Case for Randomized Field Trials in Economic and Policy Research. *Journal of Economic Perspective*, 9, 63-84.

Chatterjee, S., F. Wiseman & Perez, R. (2002). Studying Improved Performance in Golf. *Journal of Applied Statistics*, 29, 1219-1227.

Curme, M. A. & Daugherty, G. M. (2004). Competition and Pay for National Hockey League Players Born in Québec**.** *Journal of Sports Economics*, 5, 186-205.

Debrock, L., W. Hendricks & Koenker, R. (2004). Pay and Performance: The Impact of Salary Distribution on Firm-Level Outcomes in Baseball. *Journal of Sports Economics*, 5, 243-261.

Dobson, S. & Goddard, J. (2001). *The Economics of Football*. Cambridge: Cambridge University Press.

Einolf, K. W. (2004). Is Winning Everything? A Data Envelopment Analysis of Major League Baseball and the National Football League. *Journal of Sports Economics*, 5, 127-151.

Espitia-Escuer, M. & García-Cebrián, L. I. (2004). Measuring the Efficiency of Spanish First-Division Soccer Teams. *Journal of Sports Economics*, 5, 329-346.

Feess, E. & Muehlheusser, G. (2003). Transfer Fee Regulations in European Football. *European Economic Review*, 47, 645-668.

Frank, R. H. & Cook, P. J. (1995). *The Winner-Take-All Society*. New York: Free Press.

Fort, R. (2003). *Sports Economics*. Upper Saddle River, NJ: Prentice-Hall, Inc.

Gius, M. & Johnson, D. (2000). Race and Compensation in Professional Football. *Applied Economics Letters*, 7, 73-75.

Goff, B. L. & Tollison, R. D. (eds.) (1990). *Sportometrics*. Texas: Texas A&M University Press.

Grier, K. B. & Tollison, R. D. (1990). Arbitrage in a Basketball Economy, *KYKLOS*, 43, 611-624.

Grier, K. B. & Tollison, R. D. (1994). The Rookie Draft and Competitive Balance: The Case of Professional Football. *Journal of Economic Behavior and Organization*, 25, 293-298.

Hamilton, J., R. E. Romano, R. E. (1998). Equilibrium Assignments in Pairwise Team Contests: How to Form Political Slates and Tennis Teams, *European Journal of Political Economy*, 14, 101-114.

Hendricks, W., DeBrock, L. & Koenker, R. (2003). Uncertainty, Hiring, and Subsequent Performance: The NFL Draft. *Journal of Labor Economics*, 21, 857-886.

Hoffmann, R., L. Chew Ging & Ramasamy, B. (2002a). The Socio-Economic Determinants of International Soccer Performance, *Journal of Applied Economics*, 5, 253-272.

Hoffmann, R., L. Chew Ging & Ramasamy, B. (2002b). Public Policy and Olympic Success. *Applied Economics Letters*, 9, 545-548.

Houston, R. G., Jr. & Wilson, D. P. (2002). Income, Leisure and Proficiency: An Economic Study of Football Performance. *Applied Economics Letters*, 9, 939-943.

Idson, T. L. & Kahane, L. H. (2000). Team Effects on Compensation: An Application to Salary Determinants in the National Hockey League. *Economic Inquiry*, 38, 345-357.

Kahane, L. (2001). Team and Player Effects on NHL Player Salaries: A Hierarchical Linear Model Approach. *Applied Economics Letters*, 8, 629-632.

Jewell, R. T., McPherson, M. A. & Molina, D. J. (2004). Testing the Determinants of Income Distribution in Major League Baseball. *Economic Inquiry*, 42, 469-482.

Lazear, E. P. (1998). *Personnel Economics for Manager*. New York: Wiley.

Kahn, L. M. & Sherer, P. (1988). Racial Differences in Professional Basketball Players' Compensation. *Journal of Labor Economics*, 6, 40-61.

Kern, W. S. (ed.) (2000). *The Economics of Sport*. Michigan: W.E. Upjohn Institute for Employment Research.

Kochman, L. & Goodwin, R. (2004). Underdogs are Man's Best Friend: A Test of Football Market Efficiency. *Journal of Sport Economics*, 5, 387-391.

Magnus, J. R. & Klaassen, F. J. G. M. (1999). The Final Set in a Tennis Match: Four Years at Wimbledon. *Journal of Applied Statistics*, 26, 461-468.

McCormick, R. E. & Tollison, R. D. (2001). Why Do Black Basketball Players Work More for Less Money?. *Journal of Economic Behavior and Organization*, 44, 201-219.

Moy, R. L. & Liaw, T. (1998). Determinants of Professional Golf Tournament Earnings, *American Economist*, 42, 65-70.

Preston, I. & Szymanski, S. (2000). Racial Discrimination in English Football. *Scottish Journal of Political Economy*, 47, 342-363.

Rosen, S. (1981). The Economics of Superstars. *Journal of Political Economy*, 79, 1302-1319.

Shmanske, S. (2000). Gender, Skill, and Earnings in Professional Golf. *Journal of Sports Economics*, 1, 385-400.

The Official Tour de France Centennial 1903-2003 (2004). London: Weidenfeld & Nicolson.

Tcha, M. (2004). The Color of Medals: An Economic Analysis of the Eastern and Western Blocs' Performance in the Olympics. *Journal of Sports Economics*, 5, 311-328.

Torgler, B. (2004a). The Economics of the FIFA Football Worldcup. *KYKLOS*, 57, 287-300.

Torgler, B. (2004b). The Determinants of Women's International Soccer Performances, CREMA Working Paper 2004-19, Basel, Center for Research in Economics, Management and the Arts.

Torgler, B. (2004). ‘Historical Excellence’ in Football World Cup Tournaments: Empirical Evidence with Data from 1930 to 2002. CREMA Working Paper 2004-18, Basel, Center for Research in Economics, Management and the Arts.

Yilmaz, M. R. & Chatterjee, S. (2000). Patterns of NBA Team Performance from 1950 to 1998. *Journal of Applied Statistics*, 27, 555-566.

APPENDIX

TABLE A1*:*Description of the Variables

Variables	**Description**
DEPENDENT (RANKINGS)	Lower values go in line with a better individual performance
FINAL RANKING	Estimations with all *riders who finished the Tour*: *OLS*: ranking from 1 to 147 *Ordered Probit*: 4 ranking classes, 1-25 (highest value), 26-50, 51-75, 76-147 Estimations with *all the originally participating riders*: *OLS*: ranking from 1 to 163. The ranking 148 and 163 covers riders who gave up during the race It takes into account the stage in which a rider gave up (the earlier he gave up, the lower his output (higher ranking position)) *Ordered Probit*: 5 ranking classes, 1-25 (highest value), 26-50, 51-75, 76-147, 148-163 (all riders that give up)
TIME TRIALS	Estimations with *all participating riders*
TIME TRIAL 1	*OLS*: ranking from 1 to 155 *Ordered Probit*: 5 ranking classes, 1-25 (highest value), 26-50, 51-75, 76-100, 101-155
TIME TRIAL 2	*OLS*: ranking from 1 to 147 *Ordered Probit*: 5 ranking classes, 1-25 (highest value), 26-50, 51-75, 76-100, 101-147
PROLOG	*OLS*: ranking from 1 to 188 *Ordered Probit*: 5 ranking classes, 1-25 (highest value), 26-50, 51-75, 76-100, 101-188
MOUNTAIN RANKING	Estimations with *all riders who finished the Tour*: *OLS*: ranking from 1 to 70 (70 all the riders without mountain points) *Ordered Probit*: 4 ranking classes, 1-25 (highest value), 26-50, 50-69, 70+ Estimations with *all the originally participated riders*: *OLS*: ranking from 1 to 70 (70= without mountain points or gave up) *Ordered Probit*: 4 ranking classes, 1-25 (highest value), 26-50, 50-69, 70+
INDEPENDENT	
STRENGTH: *TOP 20*	Measures how many times a cyclist has been among the top 20 in his career in *previous* Tour de France events
EXPERIENCES:	Number of years an athlete is professional (min=0, max=16, mean=6.72)
YEARS PROFESSIONAL	Dummy variables: *PRO 0-5 YEARS* (reference group), PRO 6-11 YEARS, *PRO 12-16 YEARS*
NUMBERPART	Number of participations in previous Tour de France events (min=0, max=13, mean=2.85)
POSITION: *TEAM LEADER*	Dummy, 1= Team leader (defined by the teams before the race)
REGIONS	In total 188 riders from 27 different nations
FRANCE	Reference Group
ITALY	
SPAIN	
GERMANY	
NETHERLANDS	
BELGIUM	
SCANDINAVIA	Denmark, Norway, Sweden
CEE & FSU COUNTRIES	Russia, Poland, Estonia, Czech Rep., Kazakhstan, Lithuania, Slovenia, Ukraine
SWITZERLAND AND AUSTRIA	
AUSTRALIA AND NEW ZEALAND	
USA	
OTHERS	Columbia, Ireland, Luxembourg, Portugal, Venezuela

NOTES

[1] The event was cancelled between 1915-1918 and 1940-1946.
[2] It should be noticed that using 'time behind the winner' as the dependent variables does not change the empirical results obtained.
[3] Age has not been included in the estimations to avoid multicollinearity (r=0.873).
[4] The correlation between number of participations and the professional years group dummy variables are below possible critical values (for a discussion see Allison, 1999) which allows to include both factors in the estimations.
[5] There is a certain correlation between being a team leader in the Tour de France 2004 and performing well in previous Tours (r=0.4), but also below possible critical values. One big problem with multicollinearity is that it is more difficult to find statistically significant coefficients. As we will see, the coefficients for the two variables are statistically significant in most of the cases and in line with our predictions; therefore they are neither surprising nor counterintuitive, which might be a manifestation of possible problems (see Allison, 1999).
[6] The coefficient remains statistically insignificant if we omit the variable TOP20 in these estimations. The most serious danger of multicollinearity is to conclude that none of the collinear variables has an effect on the dependent variables when any of them alone has a very strong effect.
[7] The time trial two 63 percent, and the prologue only 5 percent. However, analyzing the linear relationship in a simple regression is problematic as the performances in the time trials and the mountains must be endogenous as they measure performance in different components of the Tour.
[8] Number of years a rider has been a professional.
[9] The squared term helps to investigate possible non-linear effects.