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SPORT AND MEASUREMENT OF COMPETITION**

BY

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Summary

Sport is becoming an activity of increasing importance: over time more people participate in sport (active sport consumption), more time is spent watching sport (passive sport consumption). An important part of sport consumption is passive sport consumption where production and consumption are separate: (professional) athletes engage in a contest, and fans pay to watch the contest. An important characteristic of sport that generates this demand is relative competition: the competitiveness of a particular match or league. In this paper, we set out to measure competitive balance in three sports (soccer, tennis, and skating), and assess its development over time. As we separate variation in quality of teams or athletes from randomness of outcome, we can compare relative competition in these three sports.

Key words: competitive balance, rating, soccer, tennis, skating, logit model, sport economics

JEL Code(s): C21, C25, J44, L83

1 INTRODUCTION

Sport is becoming an activity of increasing importance: over time more people participate in sport (active sport consumption), more time is spent watching sport (passive sport consumption), and even academics in economics study sport in either its own right, or as an application of theory and methods. This increasing importance has resulted in (policy) studies trying to estimate the economic value generated by sport, two examples are Ecorys (2005) and Policy Research Corporation (2008). In the first study, the total value added of football in The Netherlands (both professional and amateur) is estimated at €1.4 billion. In the second study, total value added (both direct and indirect) of sport in The Netherlands is estimated to be 1.3% of

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BBP (€7.9 billion), and the share of total employment is estimated to be 1.7%. Much larger numbers are reported by Dimitrov et al. (2006), who estimate the contribution of sport to total value added in the EU to be 3.7%, and the share of employment to be 5.4%. Besides these estimates that capture economic significance of sport in general, there are separate estimates for special large scale events, such as Olympic Games or the World Cup soccer. In such studies, focus is usually on the impact of the event. For example, Brenke and Wagner (2006, 2007) estimate that the World Cup 2006 in Germany did not have any business cycle effects. As stressed by all authors, these numbers are only rough indications of the economic relevance of sport and particular events. Sport does not enter the national accounts as a separate activity, even though some proposals to develop sport satellite accounts have been put forward. Moreover, it is hard to define 'sport' precisely, and even harder to determine all activity that can attributed to sport.

An important part of sport consumption is passive sport consumption where production and consumption are separate: (professional) athletes engage in a contest, and fans pay to watch the contest. The contest may be watched in a stadium, but also on (pay) television or the internet. The costs of consumption are more than the monetized costs of a ticket and travel, as time spent traveling and watching the game are not usually taken into account. Travel costs in particular limit the drawing power of a team or an event.

Fans are willing to pay to watch a contest, because certain characteristics of the sport product are scarce, and these characteristics are valued by the fans. Fort (2006) distinguishes four such characteristics: athletic prowess, absolute and relative quality of the contest, commonality, and the joy of victory. The best athletes are able to do things that are seemingly impossible, sport sometimes resembles performing art. Absolute quality refers to the level of play, say the difference between a soccer game in the Champions league versus a game in the Dutch Eredivisie. Relative quality is the uncertainty of outcome, or the competitiveness of a league. Commonality is the common bond between people provided by sport. People watch sport, read about it, and sport provides a topic of conversation. Loyalty to a particular team is often a source of solidarity among groups of individuals.

Sport economists have mainly focused on the second characteristic: relative quality of play. This characteristic is also known as competitive balance. Necessity of some balance of competition is unique to sport: no contest can be produced if there are no opponents. In fact, the duration of a boxing contest is directly related to the evenness of both opponents. From the point of view of the contest, it is in their mutual interest to face a strong opponent, though both boxers individually would probably prefer a weaker opponent from a sporting point of view. This is known as the Louis-Schmeling paradox, after the American boxer Joe Louis who discovered in the 1930s that the fans were willing to pay more if the contest lasted longer. The league produces competitive excitement, and it may be of interest to the league to support weaker teams so that both relative and absolute quality of play is maintained. Regulatory agencies as the NMA agree with this point of view, and allow auctioning of television rights of soccer games at a league level, as opposed to auctioning such broadcasting rights by each team individually. The European Commission has likewise agreed that the peculiar nature of sport requires sometimes somewhat collusive behavior between teams. A sport contest in a league is more valuable than an individual contest by itself: suggestive evidence is given by the smaller crowds attracted by friendly games.

In this paper, we set out to measure competitive balance in three sports, and assess its development over time. We try to separate variation in talent from variation in outcome. Given a certain talent distribution, rules and institutions in a sport determine the translation of this variation into variation of performance. Before doing so, we start with a brief theoretical discussion in Section 2. In Section 3 we measure competitive balance in soccer, both at national levels and at the level of international competitions for club teams. Changes of competitive balance (or lack thereof) will be related to changes in the economic environment of the league. In Section 4, we discuss competitive balance in two individual sports: tennis and speed skating. Most measures of competition to be discussed are parameters of relatively simple econometric models. As we separate variation in quality of teams or athletes from randomness of outcome, we can compare relative competition in the three sports that we consider. We do so in Section 5, and we also conclude in that section.

2 COMPETITIVE BALANCE: THEORETICAL DEVELOPMENTS

The first article in the academic literature to study competitive balance is Rottenberg (1956), which studies the effect of limited player mobility (the 'reserve clause') on competitive balance in professional baseball. This paper has been the point of reference of almost all other studies of competitive balance in sport played in the United States and is the origin of sport economics as a field of academic research. According to the so-called 'reserve clause', a team retained the option to renew the contract of a player under the same terms as the existing contract, with the exception that salary under the new contract could not be less than 75% of current salary. The clause has been in existence from 1876 to 1975, and its intent was to suppress the wage level of players and to limit the unequal distribution of talent between teams. Effectively, the clause created a monopsonistic market for player talent. Rottenberg questioned whether such a monopsonistic restriction would create unbalanced competition. In his paper, he assumes that the revenue function of a team is characterized by two main features. First, both absolute quality and relative quality of play enter the utility function of fans, so the revenue of a team is maximized at a win-loss record above 50% and below 100%. The second feature is that local markets differ in size, so, ceteris paribus, a team in a large market will be able to generate more revenue from an increase of quality of play than a team in a small market. Teams are assumed to maximize profits, and hire players up to equality of marginal cost of talent and marginal revenue product. Furthermore, supply of talent is elastic, but players are not perfect substitutes (this is sport!). Finally, Rottenberg assumes that the market for player contracts is competitive. It follows that in such a market the distribution of talent over teams is identical to the one where players would be free agents, which is known as Rottenbergs invariance hypothesis. The next most valuable player in a large market team may be more valuable to the team in the next largest market, and hence, that team would be willing to buy the players contract from the largest market team. Alternatively, the smaller team would be willing to outbid the largest market team in a competitive labour market that would exist if players were free agents. The effect of the reserve clause is that player salaries are lower than they would be in a competitive labour market, the difference being captured by the owner of the team. The reserve clause does not affect the distribution of talent over teams, and hence, has no effect on competitive balance. Clearly, this argument is related to the Coase Theorem, although the role of transaction costs is ignored in Rottenberg (1956). Fort (2005) argues that the invariance hypothesis of Rottenberg can be considered a weak form of the Coase Theorem (that it predates by 4 years), but that the analysis in Rottenbergs paper deals with many other issues as well.

The key assumption that drives Rottenbergs invariance hypothesis is that teams are profit maximizers. Although this assumption is reasonable for American team sports, it is not for the most important sport in Europe: soccer. A more appropriate setting might be Sloane (1971) which takes a different approach by assuming that teams are utility maximizers, subject to a budget constraint. Arguments of the utility function are playing success, average attendance, health of the league, and financial surplus, with playing success being of most importance. Under such assumptions, the mechanism that equilibrates competitive balance in Rottenbergs model, the transfer of talent between teams, is absent: no team will adopt 'running behind' as a policy (even though that may be profit maximizing). Moreover, star players will be concentrated in teams from larger markets as this maximizes their probability of success, also because teams that are successful in their national league will compete in international leagues as the Champions League and the UEFA Cup. Competition will be tougher in these international leagues, playing success in such leagues is highly valued. Using this framework, Sandy et al. (2004) show that teams from smaller markets will have a lower win-loss percentage than teams from bigger markets, and also that these teams are financially viable only for a smaller range of win percentages. In this approach, a somewhat balanced competition is not an endogenous outcome and Sloane (1971) concludes that 'there would appear to be some justification for restriction of competition in one form or another in order to maintain the degree of *sporting* competition and, therefore, the financial stability of the game' (p. 145).

From these early contributions on, the literature on competitive balance has diverged more or less along a theoretical line and an empirical line. Theoretical papers have focused on popular instruments to maintain competitive balance as the retain and transfer system, salary cap, rookie draft, revenue sharing (broadcasting rights and/or gate receipts), and the luxury tax (where salary payments above a certain threshold are taxed by the league). Effectiveness of these instruments depends on the objective function of the team: profit maximization or win maximization, and on specification of the model (is the total supply of talent fixed? do fans care about the aggregate quality of a league? etc.). As most of these models consider a league with two teams, competitive balance is measured by the ratio of wins, or by the difference of the win probabilities. An nice comparison of behavior profit maximizing teams versus win maximizing teams is given in Késenne (2007a).

The empirical literature has mainly focused on teams sports in the US, and competitive balance is usually measured by comparing the actual performance in a league to the performance one would expect if all teams would have the same playing strength (Scully 1989). This is usually implemented by estimating the standard deviation of win percentages of teams in a league. However, as argued by Vrooman (1996) there are multiple dimensions to competitive balance. There is within-season uncertainty of outcome, but also potential dominance by large market teams, and persistence of performance. These dimensions can be estimated in different ways, and we will do so in the next two sections.

3 MEASUREMENT OF COMPETITIVE BALANCE: SOCCER

Soccer is by far the most important team sport in Europe, as measured by attendance at games, number of television viewers, or financial turnover. In this study we have chosen to focus on club teams rather than national teams. The better club teams participate in a domestic league, and try to qualify for participation in the two main international leagues (the UEFA Champions League and the UEFA Cup). In this section we measure competitive balance at both levels, and we relate any changes to changes in the structure of professional soccer.

3.1 *National Soccer Leagues*

Competitive balance in national soccer leagues has been well studied theoretically, especially after the Bosman ruling in 1995. Before that year, teams were restricted in the number of non-domestic players they could field, and could demand a transfer fee for a player, even if his contract had expired.

After the Bosman ruling by the European Court of Justice in 1995, restrictions on the number of players from the EU were lifted, and players were automatically free agents upon expiration of their contract, effectively creating an open European labour market for soccer talent. This resulted in an increase in player mobility, and a concentration of playing talent with large market teams. Teams from smaller countries (for example, Sweden, Belgium, The Netherlands) have to now compete for talent with teams from much larger markets (as England, Spain, Italy).

A second major change in the structure of European soccer is the introduction of the Champions League in 1993, the market pool in 1997, and the expansion to multiple teams per country as of the 1997/1998 season. This European league has proven to be very successful in generating large television and sponsor revenues. Approximately 75% of these revenues are redistributed among the teams that participate. One half of this amount is redistributed based on performance in the Champions League, the other half is proportional to the share of television revenues generated in the country of the team. Because of this so-called market pool, teams from large markets are guaranteed to receive a large share of total revenues. The Champions League is much more lucrative than the UEFA Cup: in 2007/2008 total payout by the UEFA to the 53 teams participating in the UEFA Cup was M€37.1, while the 32 participants in the Champions League distributed M€585.6. Until 1996/1997, only domestic champions could participate in next seasons Champions League. From 1997/1998 onwards, the Champions League was expanded from 24 to 55 participants and multiple teams from the larger European leagues participated.

Theoretical consequences of these changes have been examined by different authors, Késenne (2007b) being one of the more recent ones. He proposes a simple model with two teams (a larger one and a smaller one) and two countries (a larger market and a smaller market). Revenue of a team depends on the number of stadium spectators and the size of the national market, and decreases if the win percentage is too large. Teams maximize win percentage and spend all their revenues on players. Before the opening of the labour market, the teams from the larger markets have the higher win probability in their domestic leagues. Once the labour market is liberalized, the performance gap between the teams from the larger country and those from the smaller country increases, while competitive balance within each national league does not change. He substantiates this prediction by comparing team budgets and success in the Champions league between large and small countries; he does not estimate competitive balance or its development over time.

To measure competitive balance in soccer, it is not sufficient to calculate winning percentages, as is usually done for American sports. First of all, approximately 25% of all soccer games end in a draw, and second, home advantage is an important characteristic of soccer. Home advantage has been extensively studied and the factors that affect home advantage are different from those that affect variation in quality. To separate team quality, home advantage, and luck, we use a rating model proposed by Clarke and Norman (1995). The goal difference GD_{ij} in a game between teams i (home) and j (away) depends on home advantage h_i, difference in quality $\theta_i - \theta_j$, and random factors:

$$GD_{ij} = h_i + \theta_i - \theta_j + \varepsilon_{ij}. \tag{1}$$

Home advantage h_i is the margin by which the home team is expected to win, if it were to play an opponent of equal quality: $\mathrm{E}(GD_{ij}) = h_i$ if $\theta_i = \theta_j$. The quality parameters θ_i and θ_j are not identified in model (1): both parameters can be increased with a constant c, without affecting the probability distribution of the observable outcome variable GD_{ij}. We impose the normalization $\sum_{i=1}^{n} \theta_i = 0$, with n the number of teams. This means that average quality is zero, so the θ-parameters measure quality with respect to a hypothetical team with quality zero. A team with a positive θ is better than average, a team with a negative θ is a below average team. θ_i itself can now be interpreted as the expected win margin if team i would play an average team ($\theta_j = 0$) on a neutral venue ($h_i = 0$).

Within season competitive balance is now measured as the standard deviation of θ_i, σ_θ. In a fully balanced league, all θ's will be 0 (all teams are as good as the average team), and σ_θ is 0. In an unbalanced league σ_θ will be larger. We estimate model (1) by OLS on a dataset with results on 134092 professional soccer games since 1945/1946. The data set has information on domestic leagues of seven countries, three large markets (England, Italy, and Spain), two small markets (Belgium and The Netherlands), and two intermediate cases (France and Germany). Model (1) is estimated for each season, and the estimated values for σ_θ are graphed in Figure 1. To aid the interpretation, a non-parametric regression is estimated in each panel to highlight any trends, and the vertical grey line indicates 1996. The global picture that emerges from this graph is mixed. In France and Spain there is a long term trend towards a more balanced league, but the changes of competitive balance in all countries are small compared to year-to-year variation. Within the same league, some seasons are more balanced than others.

Another dimension of competitive balance, dominance of large market teams, is calculated using this data set as well. Dominance of large market teams can be measured by calculating a concentration ratio: the number of points in the final ranking obtained by the best k teams, divided by the maximum number of points they could have obtained. This ratio is shown in Figure 2. In both England and Italy the large market teams have been able to collect more points against the lesser opponents over time. Compared to other countries, the Dutch league is relatively dominated by the best four

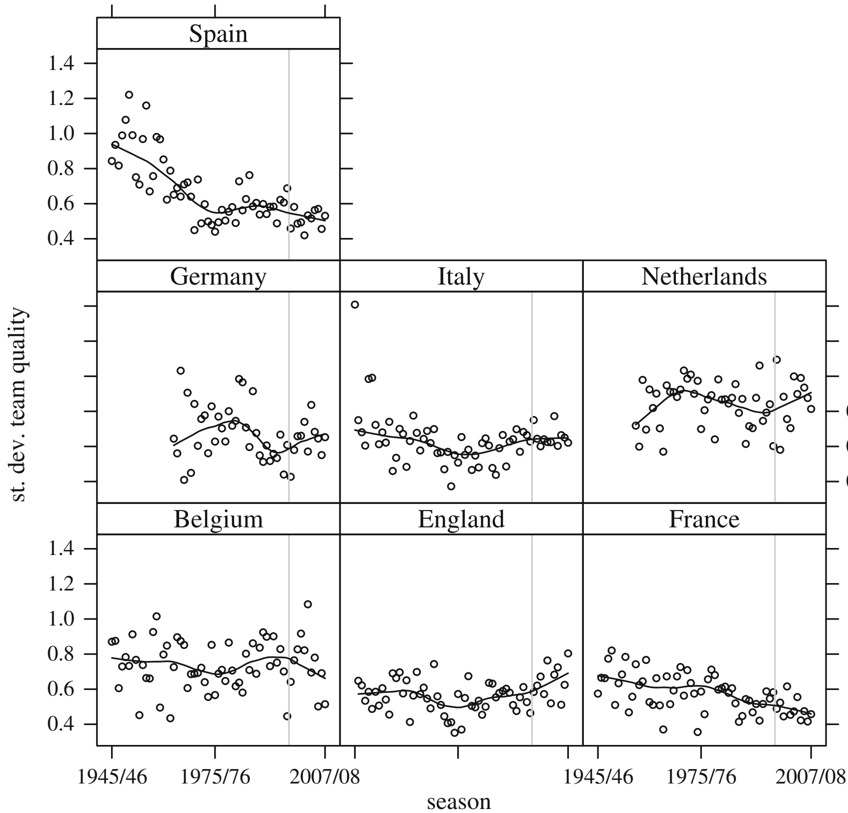

Figure 1 – Standard deviation of team quality over time

teams: they capture on average 75% of all points, both during the twenty seasons before the Bosman ruling, and after the Bosman ruling. Again, though, year-to-year variation is significant.

3.2 *International Soccer*

To our knowledge there is no empirical study of competitive balance in the Champions League or UEFA Cup. One practical problem in undertaking such a study is that teams participating in a given year may not participate the year after. If a team performs badly in the Champions League, it is likely not to qualify for next season's Champions League. Instead, it will be replaced by a stronger team from the domestic league. At the level of European competitions, competitive balance is better analyzed at country level. Most soccer fans from a given country will identify with a team from their

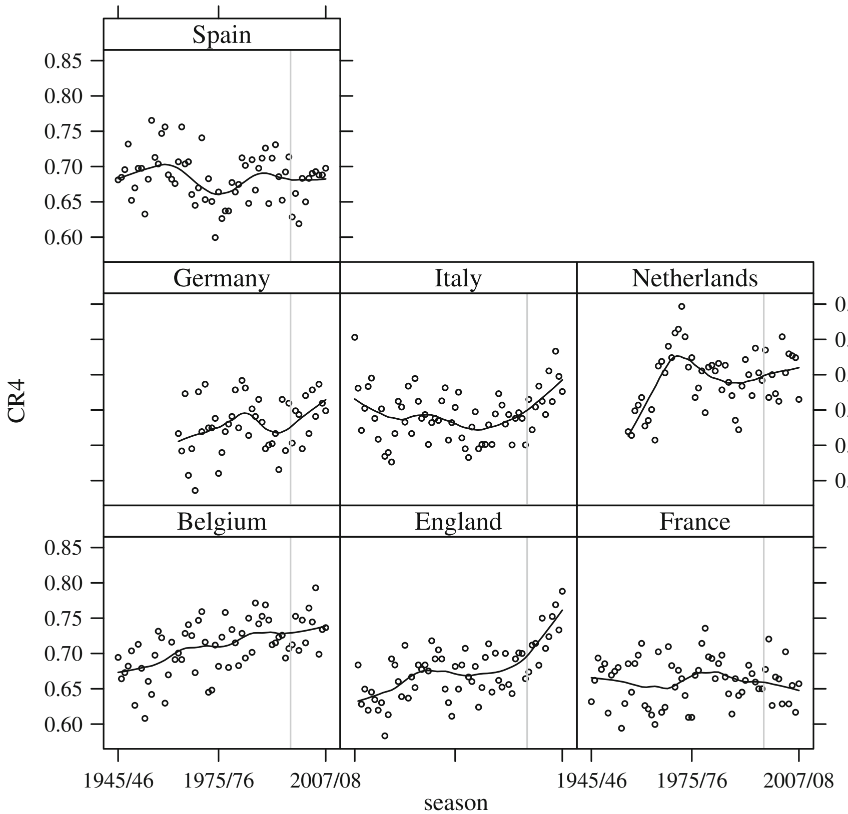

Figure 2 – Concentration ratio CR_4 over time

country, even if it is not their favorite domestic team. According to the theoretical model of Késenne (2007b) and also argued in Haan et al. (2008), soccer talent concentrates in the large leagues as a consequence of opening the labour market. Moreover, the market pool ensures that teams from countries with large television revenues receive a large share of total revenues, independent of performance. One expects success in the Champions League to be concentrated and persistent.

Concentration of success at a country level in the Champions League is large. 34 out of all 44 semi-final positions since 1997/1998 (as of that season, multiple teams per country could participate in the Champions League) have been taken by teams from the large market countries: England, Italy, and Spain. The UEFA Cup is more competitive, only 25 semi-final positions have been taken by teams from these three countries. Persistence of success has increased significantly as well. The UEFA measures performance of teams from a country by the so-called UEFA Club Competitions Associations'

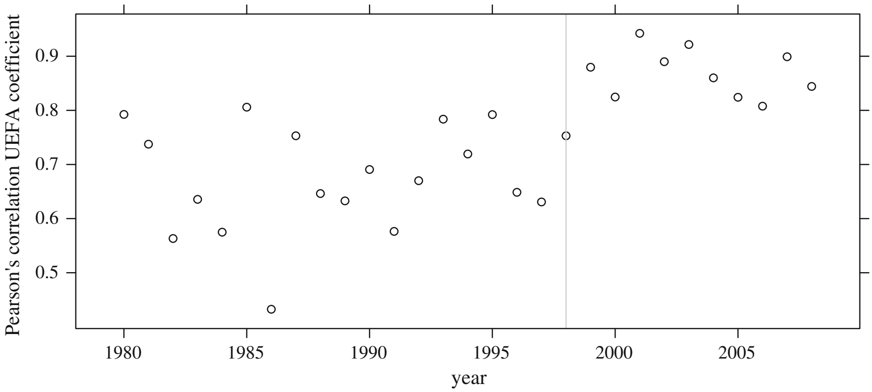

Figure 3 – Pearson's correlation of UEFA country coefficients

Coefficient. The 5-year sum of this coefficient determines the number of slots for each country in the Champions League and the UEFA Cup. In Figure 3 we show the development of the autocorrelation of this country coefficient over time. As of 1998 (indicated by the grey line), when the effects of opening the labour market were into full force, the autocorrelation increased from an average value of 0.68 (1980–1998) to 0.87 (1999–2007). Success in European leagues have become more persistent. The effect of concentration of talent in big leagues due to opening the labour market has been exacerbated by the decision of the UEFA to allow multiple teams per country in the Champions League. It is more attractive for talent to play for the third-best team in a large league, where salaries are higher, than to play for the best team in smaller leagues. The third-best team of a large league and the best team of a small league can both participate in the Champions League.

4 MEASUREMENT OF COMPETITIVE BALANCE: INDIVIDUAL SPORTS

Most studies in the literature are concerned with the analysis of competitive balance of team sports, rather than individual sports. The reason is probably that the mechanism that can be used to change competitive balance in team sports is well understood: balance can be changed by changing the distribution of talent over teams. This can be done by altering the marginal cost of talent, its marginal revenue product, or the budget restriction of the team. In individual sports, such channels are not available. Balance in individual sport is analyzed by focusing on how differences of talent translate into differences of performance. A natural definition of a fully balanced contest is then one as one where "each participant starts with an equal chance of winning" (Szymanski 2001). However, this definition is not well applicable to individual sports where performance is measured by an absolute yardstick as time taken to skate a particular distance. Considering the heterogeneity of individual sports, it is not surprising that there are no generally accepted measures of balance in individual sports. Different tailor made measures capture different dimensions, as we show in our two examples: professional tennis and speed skating. Although these two examples are interesting in their own right, they represent two different types of individual sports. In tennis, and other related sports such as badminton and table tennis, the winner is determined by a sequence of contests between two athletes and one wins a contest by beating his or her opponent in a particular game. In contrast, a skater wins based on an absolute measure of performance: time. The skater competes with all skaters in an event, which is also the case in, for example, golf.

4.1 *Tennis*

Tennis is one of the most popular individual sports. In this section, we consider measurement of competitive balance for individual professional players, so we do not analyze national leagues for teams or tournaments for country teams (as the Davis Cup). The sport is organized as a collection of tournaments, that are played throughout the year in different locations. The main tournaments are the four Grand Slam tournaments (that predate the formation of the international governing body in tennis), and ATP tournaments for men and WTA tournaments for women. Tennis is a professional sport since 1968, and the size of the pool of top tennis players is relatively large. Rules in tennis have not changed much since the early 1900s, with the exception of the introduction of the tiebreak in 1971 (to shorten the duration of a contest) and the recent introduction of the option of video replay when a decision of a linesman is contested by one of players.

Participation in tournaments provides not only monetary income to the players (prize money), but also in-kind income. Based on their performance in the tournament, players receive points. Points collected during the last 52 weeks period are added to generate a world ranking. A high position in this ranking guarantees entry to major tournaments (lower ranked players have to participate in a qualification tournament, or have to receive a wildcard from the organization), and a seeded position in the draw so that a top player does not encounter another top player early in the tournament. Moreover, highly ranked players may be invited to lucrative exhibition tournaments.

Competition in tennis has been analyzed in Du Bois and Heyndels (2007) and del Corral (2008). Both papers focus on a comparison between competition in the men's circuit and in the women's circuit. The empirical measures used in the first paper are closest to the ones we use in the previous section. Du Bois-Heyndels distinguish between four dimensions of competitive balance: match-specific uncertainty, seasonal uncertainty, inter-seasonal uncertainty, and long term dominance. Their measure of match-specific uncertainty is the number of tiebreaks in Grand Slam finals, and they find that the fraction of sets decided in a tiebreak is not different between men and women. Even though this measure can be used as an ex-post measure of match-specific uncertainty, it is less relevant as an ex-ante measure. Ex-ante measures are more likely to determine the number of spectators or the size of a television audience. Instead, an approach based on individual contests where talent is related to outcomes, is preferable. Consider a game between two players A and B, with respective world rankings R_A and R_B. If tennis is fully balanced, difference in ranking should be a non-significant or weak predictor of the outcome of the contest. To test this, we use a logit model that relates the outcome of the contest to the difference of log rankings:[1]

$$\Pr(A \succ B) = \frac{1}{1 + \exp(-\beta(\log R_A - \log R_B))}. \tag{2}$$

In this equation, we use the differences of log ranks as suggested by Klaassen and Magnus (2001) because this is a smoother measure of expected difference of performance, and because it is more consistent with the pyramid structure of tennis rankings: the quality difference between players ranked 1 and 2 is usually greater than the quality difference between players ranked 101 and 102. If tennis is fully balanced, one would find $\beta = 0$, if there is little match uncertainty β will be large and negative. β measures the efficiency of translating talent differences into performance differences. Interpretation of the parameter β in model (2) depends on the data set that is used: it can be used to describe seasonal competitive balance, but also competitive balance in particular tournaments when the data set is restricted to such tournaments.

We estimate model (2) using two data sets consisting of individual match results. For men, the data set has information about results in Grand Slam tournaments, and the two main types of ATP tournaments: Masters Tournaments and International Tournaments. The data set covers 2000–2008 and consists of 22811 matches. The dataset for women covers 2007 and 2008 only, and has 4417 match results. The estimation results are given in Tables 1 and 2. The overall estimate for β for men is -0.373 (significantly different from 0), which implies a 0.35 probability that the player ranked tenth on the World Ranking beats number two. For women, the overall estimate is -0.501 and the corresponding probability is 0.30. In the tables, we also condition on type of tournament and year. For men, every year the estimate for

1 In order to ensure a consistent model, only differences of individual specific variables can enter the index, see Koning (2008).

TABLE 1 – ESTIMATION RESULTS COMPETITIVE BALANCE, MEN'S TENNIS

	Grand Slam	Masters	International	All series
2000	−0.415	−0.279	−0.371	−0.358
2001	−0.434	−0.220	−0.326	−0.324
2002	−0.355	−0.301	−0.343	−0.336
2003	−0.439	−0.231	−0.423	−0.376
2004	−0.364	−0.311	−0.345	−0.341
2005	−0.496	−0.336	−0.484	−0.448
2006	−0.469	−0.402	−0.380	−0.404
2007	−0.563	−0.307	−0.386	−0.397
2008	−0.639		−0.352	−0.419
All Years	−0.444	−0.297	−0.379	−0.373

TABLE 2 – ESTIMATION RESULTS COMPETITIVE BALANCE, WOMEN'S TENNIS

	Grand Slam	WTA 1 or 2	WTA 3 or 4	All series
2007	−0.612	−0.554	−0.521	−0.558
2008	−0.462	−0.402	−0.484	−0.442
All Years	−0.532	−0.479	−0.504	−0.501

the Grand Slam matches is lower than the estimates for the other types of tournament. This is because Grand Slam matches are played as best-of-five sets instead as best-of-three sets. Because the contest lasts longer, it is more likely that the better player wins. This interpretation is corroborated by the fact that tournament type variation for women (who play best-of-three sets in Grand Slam tournaments as well) is not significant. Finally, we test whether the β parameter is the same for men and for women, and this hypothesis is rejected: as in Du Bois and Heyndels we find that competitive balance in women's tennis is significantly lower than in men's tennis.

Note however that the parameter β is not exogenous. The level of competition is determined by structural characteristics of tennis such as the surface of the court, the seeding system, the scoring system, design of the tournaments, size of the pool of professional players (Du Bois and Heyndels 2007). del Corral (2008) argues that riskier strategies by underdogs are more effective on faster courts and for that reason outcome uncertainty will be higher on faster playing surfaces than on slower surfaces. We do find that β is more negative on clay courts than on grass courts, but this difference is not significant, neither for men or women. β will also depend on prize incentives

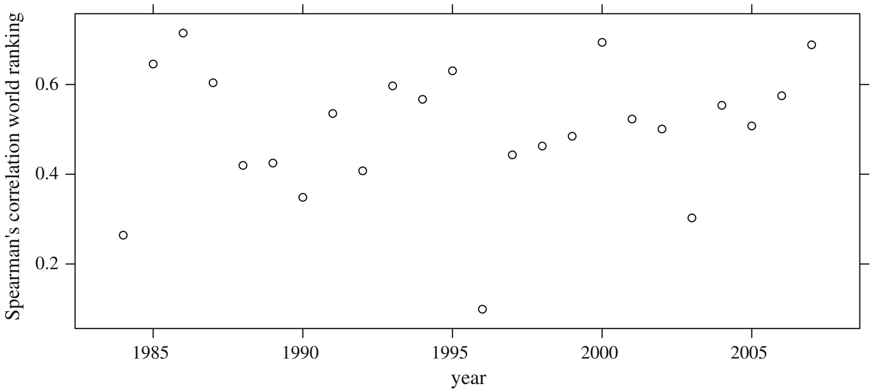

Figure 4 – Spearman's rank correlation coefficient of the top 30 ranked tennis players at year's end (men)

in a tournament. Lallemand et al. (2008) examine how female tennis players react to prize incentives and heterogeneity in ex ante players abilities. They find that outcomes of tennis matches is determined more by differences in abilities than by financial incentives. Men's tennis is examined in Gilsdorf and Sukhatme (2008) who find that increases in prize money differentials have a positive effect on the probability that the higher ranked player wins the match. Both studies confirm that financial incentives can be used as an instrument to change competitive balance. Note that both studies focus on the financial incentives of reaching the next round only, non-monetary incentives such as the increase of points in the World Ranking (and thereby, perhaps reaching a seeded position in the next tournament) are ignored.

Inter-seasonal balance can be measured by calculating Spearman's rank correlation coefficient between two consecutive year's end World Rankings. Low persistence of the World Ranking in two consecutive seasons suggests a balanced competition. We collected data on the last published World Ranking in each year from 1984 until 2008. Figure 4 displays the evolution of rank correlations of the top 30 players over time. The average rank correlation is 0.50, and clearly it varies noticeably from year to year. There is no discernable trend towards more persistence in ranking, or less persistence. Similar conclusions are drawn if we do not restrict ourselves to persistence in the top 30, but in the top 20 or top 10. The mean value of the rank correlation of the 20 best players is 0.41 during the period 1984 to 2007, that can be compared to an average rank correlation in the Dutch Eredivisie of 0.69 during the same time period. Soccer rankings are more persistent over time than the World Ranking of tennis.

4.2 *Speed Skating*

Speed skating (henceforth simply skating) is an individual sport that differs from tennis in two important aspects. First, even though the contest is between two skaters, the final ranking is based on an absolute measure of performance: time skated. The athlete competes with all opponents. Second, absolute performance of skaters has improved over time due to technological advances. Some types of technology are available to all skaters (for example, an indoor skating rink), other types were first available to a few, before the technology diffused to others over time. Some advances, as the clap skate, have been available for some time before they were adopted. Technological improvements are important, consider for example Dutch female skaters who were among the first to adopt the clap skate in the 1996/1997 season. Adoption by female skaters from other countries occurred in the following season. During that season, early adopters gained a significant improvement in performance, that disappeared when the clap skate was adopted by other skaters as well.

Absolute competition in skating is measured by personal best times, or by world records. The development of world records[2] for men over time is shown in Figure 5. Interestingly, skating times have continued to decrease over time. To illustrate the effect of new technology as the clap skate, note that the 1500 m world record (men) improved from 1.50:05 to 1.46:43 during the season the clap skate was adopted. Such a large within-season improvement cannot be explained by a sudden increase in the size of the talent pool. Other discrete improvements of technology, as for example the introduction of indoor skating rinks, show similar effects on world records.

Relative competition (competition between skaters during one particular event) can be analyzed using a similar approach to the one in Section 3.1. Here, however, we use the absolute measure of performance, and we control for the skating rink as times skated vary significantly between rinks due to altitude and cover. We estimate the random effects model

$$\log(T_{it}) = R_t + \alpha_i + \epsilon_{it}, \tag{3}$$

where T_{it} is the time of skater i in event t, R_t is the rink where the event takes place, α_i is the (unobserved) talent of skater i, and ϵ_{it} reflects all other factors. The data set has 20500 observations and has results of the main international tournaments since the 1975/1976 season. The model is estimated separately for three types of distances (500 m/1000 m, 1500 m, and 5000 m/10000 m), and for each season. The distribution of α_i is identified because there are multiple observations for a skater within one season. We do not impose that the quality of a skater (as measured by α_i) remains constant

2 In this section, all skating times are expressed as time per 500 m.

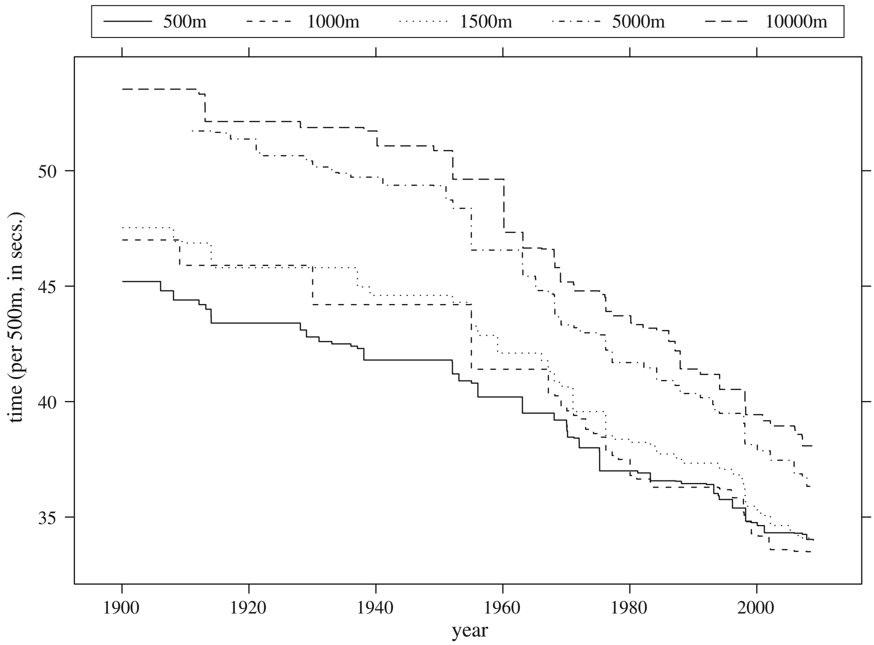

Figure 5 – Development of world records in speed skating (men)

over time, because the model is estimated separately for each season between 1975/1976 and 2006/2007. Similar to the standard deviation of estimation team quality σ_θ in Section 3.1, the standard deviation of α_i, σ_α estimates the variation of quality of skaters in a given season. To avoid excessive sensitivity to weak skaters and skaters who fell during their race, model (3) is estimated using the times of the best twelve skaters in each event. Estimates for σ_α and σ_ε remain roughly constant over time, suggesting that the distribution of individual effects has not changed that much. We find that $\hat{\sigma}_\alpha \approx 0.009$ for all three distance categories, and $\hat{\sigma}_\varepsilon \approx 0.008$. $\hat{\sigma}_\varepsilon$ is reasonably stable over time, the variation of individual heterogeneity varies more from year to year. There is no apparent trend in either component.

A second approach to measuring competition in skating is using the performance differences between top contenders. As each skater competes with all other skaters, and time is measured on a ratio scale, the time difference between the best skater and the runner up is an indication of the level of relative competition. This approach is used by Talsma and Sierksma (2008) to derive an all-time ranking of skaters. In particular, it is of interest to see whether the time difference between the fastest skaters in an event and the second or thirds best has decreased over time, as suggested by Gould (1996). In his model, it becomes progressively more difficult for the very

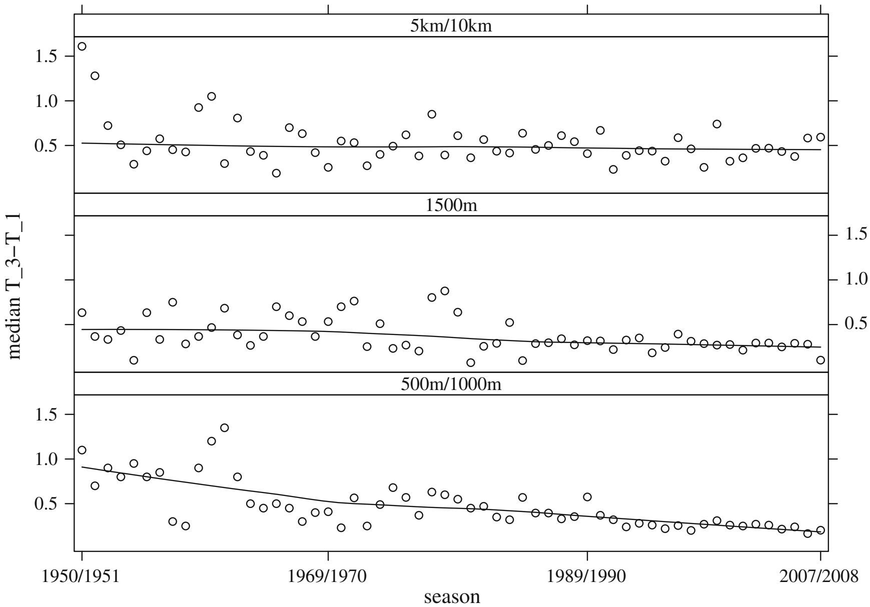

Figure 6 – The evolution of median time difference between first and third place in skating over time ($T_{(3)} - T_{(1)}$)

best athletes to improve themselves when performance is measured on an absolute scale, while the next best athletes can catch up, thereby closing the gap and reducing variation in performance. This model assumes no technological progress. As seen above, however, even the very best skaters improve themselves over time because of technological advances. In Figure 6 we graph the median time difference between the fastest skater, and the third best skater (the unit of observation is each distance event at a tournament in a given season). The World Sprint Speed Skating Championships were introduced in 1972 only, causing a significant increase in the number of skaters specializing on the 500 m and 1000 m distances. Clearly, contests on these distances have become more competitive since then: during the 1986/1987 season the time difference between the fastest and third best skater was 0.45 s, which decreased to 0.29 s in 1996/1997 and 0.17 s in 2006/2007. Such a marked increase of competition is not seen in 1500 m contests, or in 5 km/10 km contests. 5 km/10 km contests in particular are highly specialized events, with only a limited number of skaters participating. Moreover, inherent ability can manifest itself more strongly in longer distances, and the role of randomness will be smaller.

To assess persistence of quality differences over time, one could try to estimate the autocorrelation of the individual effects α_i over time. Besides the obvious difficulty of estimating α_i in the first place, it should be noted that participation in skating contests is regulated at a country level. Only a fixed (small) number of skaters can enter the competition. Second tier skaters from one country may not participate, even though they may be potentially better than first tier skaters from other countries.[3] For this reason, we measure dominance and persistence at a country level. In particular, we calculate the (inequality of) share of medals won by different countries, and the rank correlation over time based on the share of medals won. First, we consider competitiveness at country level. Skaters from only 13 countries have won medals at major events, and CR_2 (the medal share of best two countries) measured since 1995/1996 varies between 0.45 and 0.69. This shows that success in skating is highly concentrated; in a given season, only skaters from a few countries win medals. Success is persistent as well, as judged from the year-to-year Spearman's rank correlation of the medal count. During these 13 seasons, it is on average 0.77.

Absolute competition in skating continues to improve significantly, relative competition does not. Especially at the country level, success is persistent. Casual observation confirms that the sport is lacking international appeal: skating tournaments attract only a small audience in almost all countries except The Netherlands. An important instrument to improve performance is access to new technology and training methods. The emergence of professional skating teams that hire skaters from different countries, may help to disseminate such knowledge.

5 CONCLUDING REMARKS

Based on our investigations in the previous sections, can we assess which sport is most competitive? Although this depends on the distribution of talent in a particular sport we can use the models of the previous two sections to separate the effect of talent variation from outcome variation, and make a comparison of the three sports considered. As a benchmark, we compare the probability that a median team or athlete wins against the best team or athlete. This measure does not capture any persistence of performance. Details of the calculations leading to Table 3 are in the Appendix[4]. In Table 3, we give the winning probability during the 2007/2008 season, and the average winning probability between 2000 and 2008. The order of magnitude of this winning probability is remarkably similar between all sports in the long run. Especially, the 500 m/1000 m is the most competitive sport in the long run. In the short run, however, skating is least balanced and this is especially promi-

3 Obvious examples are Bart Veldkamp and Marnix ten Kortenaar, who chose to represent Belgium and Austria respectively, after failing to qualify for major events in the Netherlands.
4 The Appendix with additional tables and graphs is available on www.rug.nl/staff/r.h.koning.

TABLE 3 – PROBABILITY MEDIAN TEAM OR PLAYER WINNING AGAINST BEST TEAM OR PLAYER

	2007–2008	2000–2008
Soccer		
Netherlands	0.201	0.103
England	0.126	0.105
Tennis		
Men	0.156	0.202
Women	0.169	
Skating		
500 m/1000 m	0.088	0.231
1500 m	0.089	0.104
5000 m/10000 m	0.007	0.088

nent in the 5000 m/10000 m distance. Currently, that distance is dominated by one skater, Sven Kramer.

In this paper we have proposed different measures of competitive balance in sport. From these empirical measures, it is clear that different dimensions are relevant, and in particular persistence of performance is an important characteristic of international soccer and skating. In the case of international soccer, one can argue that this persistence is partly due to the organizational structure of the league, and therefor, can be changed by the UEFA. In national soccer leagues, competitive balance varies noticeably from year to year. Despite popular beliefs, it is hard to distinguish any trends. The separation of performance variation into variation of talent and intrinsic randomness of a given sport seems a useful approach to compare sports, and to assess the efficiency of measures to control competitive balance. In particular in individual sports, it is difficult to redistribute talent.

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