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The effect of new balls in tennis: four years at Wimbledon

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Summary
In this paper we analyse two often-heard hypotheses concerning tennis balls. The first is: are new balls an advantage to the server? They are not (at least not at Wimbledon). However, they do affect the way points are played. With new balls, more services are missed but this negative effect is compensated by winning more points if the second service is in.
The second hypothesis is: did the softer balls in the 1995 Wimbledon Championships result in lower service dominance? The answer, again, is no. The service dominance appears to have decreased over time even without special measures; the use of softer balls has had hardly any extra effect, at least not the balls used in 1995. If a faster decrease in the dominance of the service is deemed necessary, then stronger measures are called for. An obvious and easy to implement measure is to abolish the second service, which has the additional benefit of making matches more even and thus more attractive for spectators.

Keywords: Tennis, Logistic regression, Wimbledon.

1. Introduction

Tennis as a game has a long history which goes back to the Greeks and Romans. But it was not until 1870 that it became technically possible to produce rubber balls which bounce well on grass. When The All England Lawn Tennis Club decided to hold their first championships in 1877, a three-men sub-committee drew up a set of laws. Rule II stated that "the balls shall be hollow, made of India-rubber, and covered with white cloth. They shall not be less than 2 1/4 inches, nor more than 2 5/8 inches in diameter; and not less than 1 1/4 ounces, nor more than 1 1/2 ounces in weight; see Little (1995, p. 284). The quality of the tennis balls has gradually improved. From 1881-1901 the balls were supplied by Ayres, thereafter by Slazinger and Sons. Yellow balls were introduced at the 100th Championships Meeting in 1986. During the 1877 championships 180 balls were used, now more than 30,000 in one year.

During a tennis match new balls are provided after the first seven games (to allow for the

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preliminary warm-up) and then after each subsequent nine games. (Before 1955 new balls were provided at the beginning of each set.) Most commentators and many spectators believe that new balls are an advantage to the server. But is this true? This is the first of two questions we wish to investigate in this paper. The second question relates to the Wimbledon experiment in 1995, when the organisation decided to use softer balls in an attempt to lower the service dominance. The service is considered to be too dominating, especially in the men's game, and this would have a negative effect on the attraction of tennis for spectators. The second question is therefore: did the softer balls used in 1995 have the desired effect?

The simplest model in analysing tennis matches is based on the assumption that two fixed probabilities govern a match: the probability of winning a service point for both players. Then, one can calculate the probability of winning a game, set, tiebreak or match; see Hsi and Burych (1971), Kemeny and Snell (1976), and Pollard (1983). Klaassen and Magnus (1998) analyse whether the assumption of fixed probabilities of winning a point on service is realistic. Another series of papers deals with the tennis scoring system and its impact on the probability of winning a match; see Maisel (1966), Miles (1984), Riddle (1988, 1989) and the comments by Jackson (1989). Finally, the service and the first/second service strategy has been analysed by George (1973) and Gillman (1985). Gillman concludes that "missing more serves may win more points".

Many papers on the statistical analysis of tennis are theoretical and contain no data. If data are used, then these are often point-to-point data of one match, or based on end-of-match results (6-4/6-3/6-3, say). The current paper is an exception: we use point-to-point data on 481 Wimbledon matches. This means a total of 88,883 observations.

In section 2 we describe the Wimbledon data and discuss the question of weighting. Section 3 addresses the effects of new balls, while section 4 concerns the softer balls in 1995.

2. The data and two selection problems

We shall investigate the two questions using data of 481 matches played in the men's singles (MS) and ladies' singles (LS) championships at Wimbledon from 1992 to 1995. Since all matches in our data set are played on one of the five "show courts" - Centre Court and Courts 1, 2, 13 and 14 - we have data on almost one half of all singles matches played during these four years. For each of these matches we know the exact sequence of points. We also know at each point whether the first or the second service was in and whether the point was decided through an ace or a double fault. We have slightly more matches for men than for women, but of course many more sets, games and points for the men's singles than for the ladies' singles, because the men play for three sets won and the women for two. The men play less points per game than the women, because the dominance of their service is greater, as shown by Magnus and Klaassen (1998b). But the women play less games per set on average (scores like 6-0 and 6-1 are more common in the ladies' singles than in the men's singles), because the difference between seeded and non-seeded players is much greater. (See Magnus and Klaassen (1998a) for empirical evidence. At Wimbledon 16 players out of 128 are seeded.) This also leads to less tiebreaks in non-final sets for women. (At Wimbledon there is no tiebreak in the final set, that is, the fifth set in the men's singles and the third set in the ladies' singles.) Both men and women play about 60 points per set. The men play on average 230.5 points per match, the women 131.9. See Magnus and Klaassen (1998b) for further details on the data.

As noted, all matches in our data set are played on one of the five "show courts". Usually matches involving top-players are scheduled on these courts. This causes an under-representation

in the data set of matches with non-seeded players. This is, however, not the only selection problem in our data set. If two non-seeds play against each other in the quarter final, this match is likely to be scheduled on a show court. But if they play in the first round, their match is considered to be of less importance and is likely to be played on another court. After all, there are 16 first-round matches involving a seed and such matches often take precedence. Therefore, the under-representation of matches between two non-seeds is most serious in early rounds. This round-dependence in the selection of matches is also present in other matches, although it is less serious, as tables 1A and 1B show. We distinguish between round (1=first round, 7=final) and type of match (Sd-Sd for two seeded players, Sd-NSd for a seed against a non-seed, and NSd-NSd for two non-seeds). The first column in each panel contains the number of matches in our sample, the second column the number of matches actually played, and the third column the number of matches in our sample as a percentage of matches actually played.

TABLES 1A and 1B

We see that the percentage of matches of non-seeded against non-seeded (NSd-NSd) players in our data set is 24.9 for the men and 14.8 for the women. Both are lower than the percentages for Sd-NSd matches, which are themselves lower than those for Sd-Sd matches. This illustrates the first selection problem, namely the under-representation of matches involving non-seeds. (Note that in the first round of the ladies' singles there are 63 rather than 64 matches between a seeded and a non-seeded player. The reason is that Mary Pierce, seeded 13, withdrew in 1993 at the last moment. She was replaced by Louise Field, an unseeded player.)

The second selection problem, caused by the round-dependence, appears from the increasing pattern in the sampling percentages over the rounds. For example, only 32.0% of all first-round matches in the men's singles and 26.2% in the ladies' singles are in the data set, whereas all finals have been sampled.

Since we wish to make statements about Wimbledon (and not just about the matches in our sample), we account for both selection problems by weighing the matches when computing the statistics below. The weights are the inverses of the sampling percentages in tables 1A and 1B. This procedure involves an assumption, namely that within each cell the decision by Wimbledon's organisers whether a match is on a show court or not is random, so that the matches on the show courts (which are the ones we observe) are representative. One could argue that if the sample is very small compared to the population, this method would make the few observed matches too important. Most notably, in the ladies' singles we observe only 3 of the 70 matches played between two non-seeds in the second round. If these three matches were selected by the organisers to include, for example, players just outside the top-sixteen, then our method would be seriously biased for this cell. As it happens, the three matches concern players with WTA rankings 27-41, 131-143, and 22-113 and hence there is no reason to believe that these matches are not representative.

3. Is serving with new balls an advantage?

To answer this question, let us consider table 2. (In tables 2-5 our summary statistics for service characteristics are based on all points played, thus including points played during tiebreaks.) The age of the balls in games is indicated from 1 (new balls) to 9 (old balls). During the five minutes of warming up before the match begins, the same balls are used as in the first

7 games. Thus it makes sense to set the age of the balls in the first game of the match at 3. If the hypothesis that new balls provide an advantage were true, the service dominance, measured by the probability of winning a point on service, would decrease with the age of the balls. (Magnus and Klaassen (1998b) showed that the probability of winning a point on service is the best statistic to measure service quality or service dominance.) Table 2 does not support this hypothesis, at least in the men's singles. For the women the probability of winning a point on service with balls of age 9 is significantly lower than with balls of age 1, but overall there is no evidence for the hypothesis either. (In this paper "significant" means that the estimate is more than two standard errors away from its target. The standard errors are presented in brackets.)

TABLE 2

Although serving with new balls appears to provide no advantage in terms of the number of points won, table 2 shows that new balls may well affect the way points are won. For example, the probability of '1st service in' seems to increase when the balls get older, and the probability of a double fault seems to decrease, which is, of course, partly due to the increasing trend in the probability of '1st service in'. The reason for this, perhaps, is that older balls are softer and fluffier (hence more grip) than newer balls. The service is, therefore, easier to control, resulting in a higher percentage of '1st service in' and less double faults.

Both effects would result in a greater service dominance as balls get older. To show why, nevertheless, the service dominance appears to be independent of the age of the balls, we split up the probability of winning a point on service as follows:

$$\begin{aligned}&\Pr(\text{point won on service})\\ &= \Pr(\text{point won on 1st service}) + \Pr(\text{1st service fault}) \times \Pr(\text{point won on 2nd service})\\ &= \Pr(\text{point won if '1st service in'}) \times \Pr(\text{'1st service in'})\\ &\quad + \{1 - \Pr(\text{'1st service in'})\} \times \Pr(\text{point won if '2nd service in'}) \times \Pr(\text{'2nd service in'}).\end{aligned} \tag{1}$$

To analyse how these probabilities depend on the age of the balls, we specify a simple logit model with a linear function of the age of the balls as the systematic part; see McFadden (1984). For example, the probability of winning a point on service is specified as

$$\Pr(\text{point won on service}) = \Lambda(\beta_0 + \beta_1 \times \text{age balls}), \tag{2}$$

where Λ is the logistic distribution function, $\Lambda(x) = \exp(x) / (1+\exp(x))$. Table 3 presents the maximum likelihood estimation results for all probabilities in (1).

TABLE 3

As already suggested by table 2, the probability of '1st service in' increases when balls get older. One might argue that this positive effect on the probability of winning a point on the first service is counteracted by a benefit for the receiver when balls get older and thus softer and fluffier. The first service would be slower and hence easier to return. We find no evidence for this, as age has no effect on the probability of winning a point if the 1st service is in. Therefore,

in total, players win more points on their first service as balls become older.

The second service is different. The men miss less second services when using old balls, which is in line with the decreasing double fault statistics in table 2. However, if the second service is in, they win less points, but not significantly so. On balance, the quality of the second service, measured by the probability of winning a point on the second service, is independent of the age of the balls.

For the women the quality of the second service does depend on the age of the balls. The second service is easier to return with older balls, which makes the quality of the second service depend negatively on the age of the balls.

Formula (1) can now be used to show that, on balance, the age of the balls does not affect the service dominance. It is true that older balls lead to more points won on first service. However, both men and women get less opportunities to score points on their second service, as the probability of missing a first service decreases. Moreover, the women score less points on their second service. On balance, the effects on the first and second service offset each other, so the age of the balls does not affect the service quality.

A second interpretation of the question whether serving with new balls provides an advantage is that newer balls may benefit the server only in the first game they are used (age is 1). It may be the transition from old, soft and fluffy balls to new, hard balls that is difficult to cope with for the receiver and/or server. To analyse this we add a dummy variable for balls of age 1 to the logit models used above. However, there is no evidence for an effect of this dummy on the probabilities in table 3. Only for the probability of '2nd service in' for the ladies' singles has the dummy a significantly negative effect. This is in line with the high percentage of double faults with new balls in table 2. Including the dummy does not change the effect of the age variable essentially.

4. Softer balls

We now turn to another aspect of tennis balls. A major discussion in tennis concerns the service dominance and the effect it has on the attraction of tennis as a spectator sport. This, of course, is particularly true on fast grass courts such as at Wimbledon. Many proposals have been made to reduce the dominance of the service: making the net higher or the service court smaller, abolishing the second service, using softer balls. This last proposal was put into effect at the 1995 Wimbledon Championships. Has this resulted in less service dominance?

Before we can address this question, we need to know something about the weather, since this also affects a match. If the weather had been very different in 1995 than in the three previous years, then it would have been difficult to make proper comparisons. The Wimbledon weather has been documented by Little (1995) - the weather has not been very different in the four years of our observations.

In table 4 the four years are compared through some service characteristics. The service dominance in 1995 did not differ significantly from the years before. In 1995, 64.0% (0.4%) of the points in the men's singles were won on service, compared to 64.5% (0.2%) in the three years before. For the women the conclusion is the same. Hence, the softer balls used in 1995 did not have the desired effect. Note that this is in line with the absence of any effect of older, and thus softer and slower balls on the service dominance, which we showed in the previous section.

TABLE 4

Table 4 also shows that the softer balls in 1995 seem to have had some effect. The men hit significantly more aces and double faults in 1995 and both men and women missed more first services. The low percentages of '1st service in' and '2nd service in' for 1995 are, however, peculiar, since the analysis of the new balls hypothesis showed that older (and thus softer and slower) balls lead to more instead of less services in. However, a more careful investigation of table 4 shows that the deviations have little to do with the softer balls. Over the whole period of four years the percentage of aces and double faults has gradually increased for the men, and the percentage of '1st service in' has gradually decreased for both men and women.

To get a clear distinction between the trend and any additional effect of the softer balls, we use a similar logit model as before. The trend variable is the year of tournament (year= 92,93,94 or 95) and a dummy for 95 is used to capture any additional effect of the softer balls in 1995. Hence, we write all probabilities in (1) as logistic distribution functions of $\beta_0 + \beta_1 \times$ year $+ \beta_2 \times$ dummy 95. For example,

$$\Pr(\text{point won on service}) = \Lambda(\beta_0 + \beta_1 \times \text{year} + \beta_2 \times \text{dummy 95}). \qquad (3)$$

Table 5 shows the maximum likelihood estimation results. In only two cases is the year 1995 different after correction for the time trend. However, only for the men's '2nd service in' the 1995 dummy has an effect that might be attributed to the softer balls. The negative effect for the women's '1st service in' cannot be due to the softer balls, as we showed in the previous section that softer balls have a positive effect on this service characteristic. Our conclusion is thus that the softer balls in 1995 had hardly any effect on service characteristics.

TABLE 5

Table 5 can also be used to analyse whether and how the game of tennis at Wimbledon has evolved from 1992 to 1994, particularly the way servers win their points. We observe a gradual decrease in the service dominance, that is, the probability of winning a point on service, both for the men and the women. For the women this can be attributed solely to a decrease in the probability of winning a point on the first service. (Removing the insignificant 1995 dummy leads to a significantly negative effect of the year on this probability.) More specifically, it has become harder to win a point on service if the first service is in. This may be due to an improvement in the return of service by professional players, as is sometimes claimed.

This claim is also supported by the results for the men in table 5. The men apparently take more risk on their first and second services, leading to more aces (see table 4), lower percentage of '1st service in' and more double faults. Are they pushed to hit more difficult services, because of the better returns? Apparently the services are still not difficult enough to increase the probability of winning a point on service if the service (1st or 2nd) is in. This is again in line with the improvement-of-return hypothesis. We see this as the main cause behind the gradual decrease in the service dominance.

So, the service dominance has decreased over time without special measures. The use of softer balls has hardly any effect, at least not the balls used in 1995 at Wimbledon. If a faster decrease in the dominance of the service is deemed necessary, then stronger measures are called for. Magnus and Klaassen (1998b) have argued that abolishing the 2nd service, which is an obvious and easy to implement measure, has the additional benefit of making matches more even and thus more attractive for spectators.

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TABLE 1A

Number of matches in the sample and in the population: men's singles

round	Sd-Sd			Sd-NSd			NSd-NSd			total		
	sample	pop.	perc.	sample	pop.	perc.	sample	pop.	perc.	sample	pop.	perc.
1	-	-	-	48	64	75.0	34	192	17.7	82	256	32.0
2	-	-	-	46	54	85.2	16	74	21.6	62	128	48.4
3	-	-	-	39	41	95.1	16	23	69.6	55	64	85.9
4	8	9	88.9	15	15	100.0	8	8	100.0	31	32	96.9
5	7	7	100.0	9	9	100.0	0	0	-	16	16	100.0
6	7	7	100.0	1	1	100.0	0	0	-	8	8	100.0
7	4	4	100.0	0	0	-	0	0	-	4	4	100.0
Total	26	27	96.3	158	184	85.9	74	297	24.9	258	508	50.8

Table 1B

Number of matches in the sample and in the population: ladies' singles

round	Sd-Sd			Sd-NSd			NSd-NSd			total		
	sample	pop.	perc.	sample	pop.	perc.	sample	pop.	perc.	sample	pop.	perc.
1	-	-	-	43	63	68.3	24	193	12.4	67	256	26.2
2	-	-	-	43	58	74.1	3	70	4.3	46	128	35.9
3	-	-	-	42	48	87.5	12	16	75.0	54	64	84.4
4	8	8	100.0	20	21	95.2	2	3	66.7	30	32	93.8
5	11	12	91.7	3	3	100.0	1	1	100.0	15	16	93.8
6	6	6	100.0	1	2	50.0	0	0	-	7	8	87.5
7	4	4	100.0	0	0	-	0	0	-	4	4	100.0
total	29	30	96.7	152	195	77.9	42	283	14.8	223	508	43.9

TABLE 2
Service characteristics depending on the age of the balls

	percentage of ...	1	2	3	4	5	6	7	8	9	total
MS	aces	8.7 (0.4)	7.9 (0.4)	8.6 (0.3)	7.7 (0.3)	8.2 (0.3)	8.3 (0.3)	8.5 (0.3)	8.4 (0.4)	7.2 (0.3)	8.2 (0.1)
	double faults	5.8 (0.3)	5.3 (0.3)	5.8 (0.3)	6.6 (0.3)	5.4 (0.3)	5.6 (0.3)	4.9 (0.3)	5.1 (0.3)	5.1 (0.3)	5.5 (0.1)
	points won on service	64.7 (0.6)	63.4 (0.6)	64.2 (0.6)	64.8 (0.6)	64.0 (0.6)	64.1 (0.6)	65.8 (0.6)	64.3 (0.6)	64.3 (0.6)	64.4 (0.2)
	1st services in	58.9 (0.6)	60.2 (0.6)	58.4 (0.6)	58.6 (0.6)	59.1 (0.6)	59.1 (0.6)	59.7 (0.6)	60.3 (0.6)	61.0 (0.6)	59.4 (0.2)
LS	aces	2.4 (0.3)	2.5 (0.3)	3.4 (0.3)	3.2 (0.3)	3.8 (0.3)	2.7 (0.3)	3.7 (0.3)	3.7 (0.3)	2.1 (0.3)	3.1 (0.1)
	double faults	6.7 (0.5)	5.4 (0.5)	5.8 (0.4)	5.2 (0.4)	5.6 (0.4)	4.0 (0.3)	5.2 (0.4)	5.4 (0.4)	6.4 (0.4)	5.5 (0.1)
	points won on service	56.2 (0.9)	56.3 (1.0)	55.9 (0.8)	54.8 (0.8)	58.4 (0.8)	56.2 (0.8)	57.7 (0.9)	55.9 (0.9)	53.3 (0.9)	56.1 (0.3)
	1st services in	58.3 (0.9)	61.0 (1.0)	61.3 (0.8)	56.9 (0.8)	61.1 (0.8)	61.9 (0.8)	61.9 (0.8)	63.9 (0.9)	61.4 (0.9)	60.8 (0.3)

TABLE 3

Service characteristics depending on the age of the balls: logit estimation results

probability of ...	MS		LS	
	constant	age of balls	constant	age of balls
point won on service	0.580 (0.019)	0.003 (0.003)	0.269 (0.027)	-0.005 (0.005)
point won on 1st service	-0.293 (0.018)	0.007* (0.003)	-0.593 (0.027)	0.019* (0.005)
point won if 1st service in	1.001 (0.027)	0.002 (0.005)	0.443 (0.035)	0.011 (0.006)
1st service in	0.341 (0.019)	0.008* (0.003)	0.340 (0.027)	0.020* (0.005)
point won on 2nd service	0.057 (0.029)	-0.001 (0.005)	0.041 (0.042)	-0.036* (0.008)
point won if 2nd service in	0.414 (0.031)	-0.006 (0.006)	0.378 (0.046)	-0.043* (0.008)
2nd service in	1.766 (0.041)	0.017* (0.008)	1.820 (0.061)	-0.001 (0.011)

TABLE 4

Service characteristics depending on the year of tournament

percentage of ...	MS					LS				
	1992	1993	1994	1995	92-94	1992	1993	1994	1995	92-94
aces	7.7 (0.2)	8.1 (0.2)	8.1 (0.2)	8.9 (0.3)	8.0 (0.1)	3.2 (0.2)	3.6 (0.2)	2.4 (0.2)	3.3 (0.2)	3.0 (0.1)
double faults	4.6 (0.2)	5.2 (0.2)	6.2 (0.2)	6.2 (0.2)	5.3 (0.1)	5.2 (0.3)	5.7 (0.3)	5.3 (0.3)	5.8 (0.3)	5.4 (0.2)
points won on service	64.9 (0.4)	64.9 (0.4)	63.9 (0.4)	64.0 (0.4)	64.5 (0.2)	57.0 (0.6)	56.6 (0.6)	55.4 (0.6)	55.4 (0.5)	56.3 (0.4)
1st services in	61.6 (0.4)	60.4 (0.4)	58.5 (0.4)	56.9 (0.4)	60.1 (0.2)	61.1 (0.6)	60.5 (0.6)	62.2 (0.6)	59.6 (0.5)	61.3 (0.3)

TABLE 5

Service characteristics depending on the year of the tournament: logit estimation results

probability of ...	MS			LS		
	constant	year	dummy 95	constant	year	dummy 95
point won on service	2.643 (1.088)	-0.022 (0.012)	0.022 (0.031)	3.333 (1.527)	-0.033* (0.016)	0.030 (0.042)
point won on 1st service	2.809 (1.049)	-0.033* (0.011)	0.000 (0.030)	1.084 (1.557)	-0.017 (0.017)	-0.043 (0.043)
point won if 1st service in	-1.667 (1.513)	0.029 (0.016)	0.013 (0.045)	5.105 (1.982)	-0.049* (0.021)	0.048 (0.054)
1st service in	6.506 (1.064)	-0.066* (0.011)	-0.004 (0.030)	-1.529 (1.555)	0.021 (0.017)	-0.117* (0.043)
point won on 2nd service	4.792 (1.652)	-0.051* (0.018)	0.045 (0.046)	1.637 (2.472)	-0.019 (0.027)	0.049 (0.068)
point won if 2nd service in	2.224 (1.805)	-0.020 (0.019)	0.003 (0.051)	1.657 (2.647)	-0.016 (0.029)	0.053 (0.073)
2nd service in	13.479 (2.440)	-0.125* (0.026)	0.154* (0.067)	3.702 (3.565)	-0.020 (0.038)	0.013 (0.097)