Rational Adversaries? Evidence from Randomized Trials in the Game of Cricket

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Abstract

In cricket, the right to make an important strategic decision is assigned via a coin toss. We utilize these "randomized trials" to examine (a) the consistency of choices made by teams with strictly opposed preferences, and (b) the treatment effects of chosen actions. We find significant evidence of inconsistency, with teams often agreeing on who is to bat first. Estimated treatment effects show that choices are often poorly made since they *reduce* the probability of the team winning.

Keywords: decision theory, zero sum situation, randomized trial, treatment effects.

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1 Introduction

While the assumption of rational behavior underlies most economic theory, this is being questioned by the recent rise of behavioral economics. Since Kahneman and Tversky's pioneering work, many experiments demonstrate that subjects have a variety of biases when they deal with uncertainty. Experimental subjects also do not perform well when playing simple games — O'Neill's (1987) experiments on games with a unique completely mixed equilibrium are a case in point. The interpretation of these results is however debatable. Subjects in experiments are placed in an unfamiliar and somewhat artificial situation, and usually have insufficient opportunities to learn how to choose optimally. Their incentives to do so may also be limited.

Professional sports provide several instances of alternative real life experiments, which are not subject to some of these criticisms. Professional players spend their prime years learning how to play optimally, and are repeatedly involved in familiar situations. They also have high-powered incentives. The rules of the game are clear cut, as in experiments, even though they have not been designed with academic economists in mind. An emerging literature has exploited this data source. Walker and Wooders (2001) study the serve behavior of professional tennis players, and find that behavior corresponds closely to the mixed strategy equilibrium of the associated game. Similar support for the mixed equilibrium is found in the case of penalty kicks in soccer (Chiappori et. al. (2002) and Palacios Huertas (2003)). These results contrast rather sharply with the negative experimental results on games with a unique mixed equilibrium. Given the incentive effects and the opportunities to learn, violations of optimality in professional sports also need to be taken seriously by economists. Thus Romer (2003) uses dynamic programming to analyze strategy in American football, and finds that decisions are not made optimally.[1]

This paper investigates the rationality of strategic decisions in the game of cricket. Cricket is a game played between two teams, one of which must bat first, while the other team fields. The roles of the teams are then reversed. The decision, as to whether a team bats first or fields first, is randomly assigned to one of the two teams, via the toss of a coin. From a decision theoretic point of view, this strategic decision combines several important qualities. First, batting or fielding is not

[1]Relatedly, Duggan and Levitt (2002) examine collusion in sumo wrestling, while Ehrenberg and Bognano (1990) have studied the incentive effects of golf tournaments. Garciano et. al. (2001) use data from soccer to examine social pressures on refereeing decisions. There is also substantial earlier literature examining the industry of sport or its labor market.

assigned by the coin toss, but must be *chosen* by the winner. Second, this choice is recognized by cricket players to be an important decision, since the conditions for batting or fielding can vary over time, with variation in the weather and condition of the natural surface on which the game is played. Third, the optimal choice is non trivial, since it is not constant, but depends upon natural conditions — in the matches we consider, the team winning the toss has chosen to bat on roughly half the occasions. Finally, from an economist's standpoint, the right to decide is assigned via a coin toss thereby providing a randomized trial *par excellence*, and allowing us to test for the rationality of choices.

Our tests of rationality are of two types, internal consistency and external validity. The intuition underlying our empirical test of consistency in decision making is straightforward. We start from the presumption that all the multifarious considerations that influence the decision, including the nature of the pitch, the strengths of the respective teams and the weather (i.e. the *state of the world)*, are only of relevance through their effect on two probability distributions — the probability distribution over the outcomes of the game when team 1 bats first, and the probability distribution over outcomes when team 2 bats first. If team 1 wins the toss, it will choose to bat if it prefers the former probability distribution to the latter probability distribution. If this is so and if the interests of the teams are perfectly opposed, this implies that team 2 will prefer the latter probability distribution to the former, and must choose to bat first if it wins the toss.[2] Thus at any state of the world, 1 chooses to bat first if and only if 2 chooses to bat first. Of course in any match, we only observe one of these decisions, since only one of the teams wins the toss. However, since identity of the winner of the toss is a random variable which is independent of the state of the world, this allows us to aggregate across *any* subset of the set of possible states, to make the following probabilistic statement: the probability that team 1 bats first given that it wins the toss must equal the probability that it fields first given that its opponent wins the toss. Thus our test of rationality is a test of the *consistency* of the decisions made by a team and its opponents. This is akin to tests of revealed preference theory — while revealed preference theory tests the consistency of a single decision maker who is assumed to have stable preferences over time, we test the consistency of decisions of *pairs of agents* whose interests are perfectly opposed. Our basic finding is that is that the consistency of decisions is vi-

[2]This assumes that teams have symmetric information regarding the state of the world. Section 4 discusses the modifications that must be made in the case of asymmetric information.

olated for an important class of cricket matches — one day internationals which are played in the day-time — since some teams systematically choose differently from their opponents. We explore different explanations for this lack of consistency, including asymmetric information, but conclude that the best explanation is in terms of teams *overweighting* their own strengths (and weaknesses) and underweighting the strengths of their opponents in making decisions.

These randomized trials also allow us to infer the external validity of decisions since we can infer the effects of the choices upon the outcome of the game. Choices are endogenous, and their effects also heterogenous, since this depends upon the state of the world. Nevertheless, since the right to choose is assigned via a coin toss, we show that if decisions are made optimally, one can infer the average effect of a treatment (such as batting first), conditional on the treatment being optimal. Consider a state of the world ω where batting first is optimal, and where team 1 garners an advantage $\lambda(\omega) > 0$ from choosing to bat, where λ is the difference between win probabilities from team 1 batting first and fielding first. Then at this state of the world, its opponent team 2 has an identical advantage $\lambda(\omega)$ from batting first. Thus one has a randomized trial where the winner of the toss is assigned to the treatment group and its "twin", the team losing the toss, is assigned to the control group. Our substantive findings are intriguing since there is strong evidence that teams are making decisions sub-optimally in one day international day matches, since the effect of choosing to bat first is estimated to *reduce* the probability of winning. We therefore find violation of both internal consistency and external validity for the main class of international one day matches, those played in the day time. For day-night matches, which are partially played at night-time, both consistency and external validity are not rejected, possibly because teams have a strong preference for batting first in daylight, which the data suggests is empirically sound.

The layout of the remainder of the paper is as follows. Section 2 sets out our model of the basic strategic decision, and derives its empirical implications. Section 3 reports the empirical results. Section 4 explores various explanations for anomalous results such as asymmetric information and agency problems The final section concludes.

2 Modelling Decisions

At the highest level the game of cricket is played between representative national teams. There are two forms of the game at this level, test matches and one day internationals. In a one day match, each team bats once, with a maximum period for its innings (unless it is bowled out), the winner being the team that scores more runs while batting. With essentially only two outcomes, win or loss, risk preferences are irrelevant, implying an immediate zero sum property on preferences so long as each team prefers to win. This makes one day matches ideal for our analysis.[3] The sequence in which the teams bat is decided via the toss of a coin. The captain of the team that wins the toss has to choose whether to bat first or to field first. This decision is acknowledged to be of strategic importance by cricket players and observers, since the advantage offered to the bowlers varies with the weather, and the condition of the pitch, the natural surface on which play takes place. Unlike baseball, the ball usually strikes the pitch before it reaches the batsman, and may bounce or deviate to different degrees depending upon the pitch. The ability to exploit the pitch and conditions also depends upon the type of bowler. Fast bowlers benefit when there is moisture in the pitch, early in the match, since this increases the speed and bounce off the pitch. Fast bowlers also like overcast conditions. On the other hand, bowlers who spin the ball are more effective later in a game, after the pitch has been worn out through play. The pitch may also deteriorate, so that it becomes rather difficult to bat towards the end of a match. Playing conditions are also rather different between matches which are played entirely in the day (which we call *day matches),* and matches which are played partially at night (*day-night matches*). In day-night matches, the team batting second bats at night under floodlights, and may be at a disadvantage.

The team that bats second has the advantage of knowing the rate at which it must score in order to win the game. The team batting first sets the score, and faces the risk that if attempts an ambitious target, it may be bowled out for a low score. On the assumption that the batting team can choose the scoring rate (at the cost of losing the wickets of its batters stochastically more quickly), Clark (1988) and Preston and Thomas (2000) use a dynamic programming analysis to show that the team batting second has a significant advantage.

We set out the following simple model of decision making in the game of cricket.

[3] In test matches, a draw occurs a significant fraction of the time, so that players' risk preferences are relevant. A companion paper (Bhaskar, 2004) analyzes decisions in test matches.

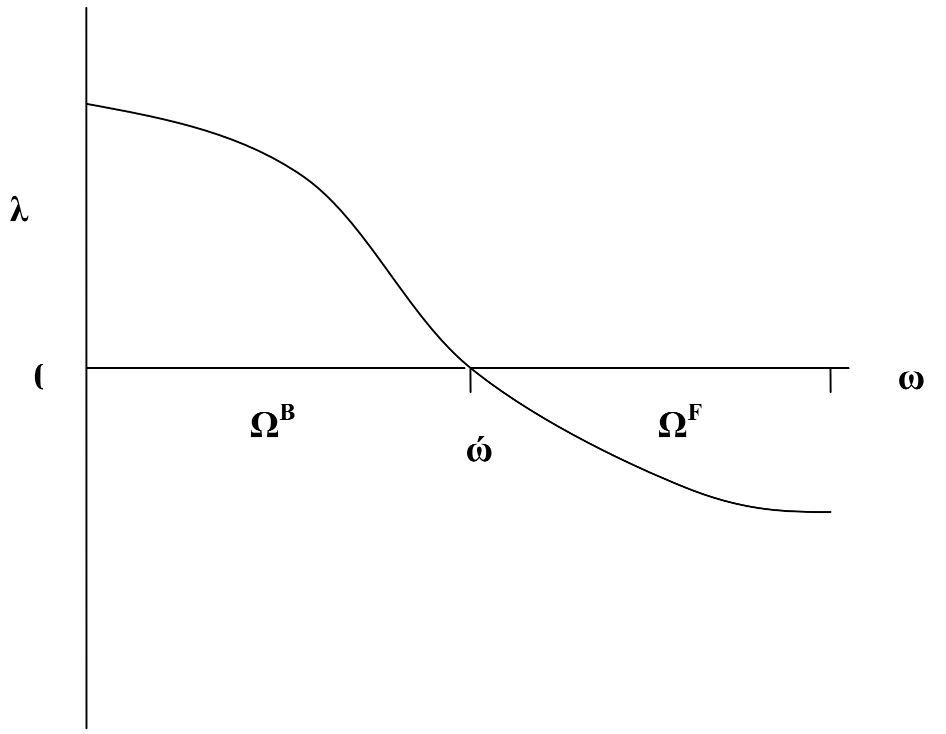

Fig. 1: Advantage From Batting First

Let the two teams be 1 and 2, and let us describe the outcome from the standpoint of team 1. Consider the decision of the team, as to whether bat first or to field first. This decision is made by the captain who wins the toss, and many factors will influence this decision. To model this, let ω denote the state of the world — this includes a complete specification of all the circumstances which affect the outcome of the cricket match, including the quality and type of bowlers in each side, the quality of the batsmen, the weather, the state of the pitch, etc. Let Ω denote the set of all possible states of the world. Thus ω determines a pair $(p(\omega), q(\omega))$, where $p(\omega)$ denotes the probability that team 1 wins given that it bats first, and $q(\omega)$ denotes the probability of a win when it fields first. We shall assume symmetric information, i.e. that the state ω is observed by team 1 and by team 2 before they make their decision. Let $\lambda(\omega) = p(\omega) - q(\omega)$.

Figure 1 graphs λ as a function of ω, where Ω is depicted as a compact interval, with states arranged in order of decreasing λ. It is immediate that team 1 will choose to bat first at states ω where $\lambda(\omega) > 0$. Similarly, team 1 will choose to field first if $\lambda(\omega) < 0$. Finally, we assume that the set of states ω such that $\lambda(\omega) = 0$ is negligible, i.e. this set has zero prior probability.

Turning to team 2, it will choose to bat first if its probability of winning is higher than when fielding, i.e. if $1 - q(\omega) > 1 - p(\omega)$, i.e. if $\lambda(\omega) > 0$. We deduce that the set of states where 1 bats first is the same as the set of states where 2 bats first, so that the two teams can never agree on who is to bat first, a *no agreement result.* Let Ω^B(resp. Ω^F) denote the set of states where batting first (resp. fielding first) is optimal.

At any state, we only observe the decision of one of the two players. However, the right to take this decision is via a coin toss, which is independent of the state of the world. To an outside observer, the probability that team 1 bats first equals the probability that $\omega \in \Omega^B$, $\Pr(\Omega^B)$. Similarly, the probability that team 2 bats first also equals the $\Pr(\Omega^B)$. Thus if we consider any two teams, the observed decisions of team 1 when it wins the toss are realizations of a Bernoulli random variable with success probability $\Pr(\Omega^B)$. Similarly, under no agreement, the decisions of team 2 are also realizations of the same Bernoulli random variable. Under the null hypothesis induced by the no agreement result, the *proportion* of times that 1 bats first on winning the toss is equal to the proportion of times that 2 bats first on winning the toss. Our basic tests of this null hypothesis are based on the Pearson test statistic which is distributed as χ^2 variable with one degree of freedom.

Two points are worth making here. First, the specification of the state of the world can be very general, and can encompass a range of factors. Thus, we may fix the identity of team 1 (say to be a specific country, e.g. Australia). We may however allow the identity of team 2 to vary, so that we consider Australia's games against all its opponents, since the identity of the opponent may be encapsulated in the state of the world ω. The null hypothesis may thus be reformulated as follows: the probability that team 1 bats first when it wins the toss equals the probability that it fields first when it loses the toss. Second, it is easily verified that the null hypothesis also holds for *any* identifiable subset Ω' of Ω, since we may rephrase the above statements in terms of conditional probabilities. Thus the probability that team 1 bats first when it wins the toss given that $\omega \in \Omega'$ must equal the probability that it fields first when $\omega \in \Omega'$.[4]

The no agreement result relies on the fact that the teams have strictly opposed

[4]Aggregation does not cause us to wrongly reject the null, though it may reduce the power of test.

von-Neumann Morgenstern preferences over the set of outcomes. Such an opposition of preferences is immediate when the game has only two possible outcomes, win and loss, and where each team prefers to win. However, the match can also have "no result" when bad weather curtails play, so that the number of overs bowled is below the stipulated minimum. Since the outcome "no result" largely depends upon exogenous factors such as the weather, its probability is unlikely to be affected by who bats first, and our analysis can be straightforwardly extended to allow for this. A match can also be tied when the scores of the two teams are exactly equal — this occurs with probability less than 0.01, which suggests that the *marginal* effect of the batting/fielding choice upon this probability is minuscule. Thus the no-agreement result appears to be well founded.

The no-agreement result is straightforward, and follows from the Harsanyi doctrine, that differences in beliefs must reflect differences in information. However, it does not seem straightforward to professional cricketers, who often suggest that a team might choose in line with its strengths. Thus they find it entirely reasonable that a team with a strong batting line up could choose to bat first, while its opponent with good fast bowlers might choose to field first.[5] This suggests a natural alternative hypothesis: that teams overweight their own strengths when making a decision, while underweighting the strengths of their opponents. Consider for example a situation where team 1 has a strong fast bowling attack, while team 2 does not have such a strong attack of fast bowlers, but has good batsmen. Thus team 1 may choose to field first since it feels that its bowlers may be able to exploit the conditions early in the match. On the other hand, team 2 may prefer to bat first, since it has less confidence in its fast bowlers. If teams did have asymmetric strengths, and if they overweight their own strengths, then the null hypothesis would be systematically violated — in this example, team 1 would bat first less frequently than team 2 did.[6]

Our tests of the no-agreement result can be viewed of tests of the *consistency* of

[5] In his famous book, *The Art of Captaincy,* former England captain Mike Brearley (1985) devotes a chapter to the choice made at the toss, and recounts several incidents where both captains seem to agree. This includes one instance where the captains agreed to forgo the toss, since they agreed on who was to bat first, and another instance where there was some confusion on who had won the toss, but this was resolved since the captains agreed on who should bat first.

[6] Even if teams' behavior is in line with the alternative (overweighting) hypothesis, the null will not be rejected as long as teams have symmetric strengths. Also, since the strengths of various teams change over time, the alternative suggests that one should condition on finer partitions of Ω while testing of the null. Note however that the null hypothesis is valid at any level of aggregation or disaggregation.

the decisions made by the captains of the two teams. As such, these tests are similar to tests of single agent decision theory (e.g. tests based on individual consumption data or experiments), the novelty here being that we are able to use the decisions made by different agents.

We now turn to the effects of the choices made upon the outcome of the game. Let us start by asking, what is the advantage conferred by batting first, on winning the toss? We may of course compute the proportion of wins by the team that wins the toss and bats first. However, the decision to bat first is clearly endogenous (unlike the winning of the toss). This maybe related to the treatment effects literature, as in Heckman et. al. (1999). Let batting first be the treatment. Clearly, batting first is optimal only for a subset of states, Ω^B. Thus our interest is the *average effect of the treatment when the treatment is optimal,* i.e. upon $\mathbf{E}(\lambda(\omega) \,|\, \Omega^B)$. This is more interesting than the unconditional expectation of λ, which is the average treatment effect (although this can also be estimated). A medical analogy maybe useful here. Think of two procedures, surgical and non-surgical, which maybe chosen by a doctor. One is interested in the effect of surgery upon some outcome when surgery is optimal, not the average effect of surgery, including states where surgery is clearly suboptimal. The difficulty in the medical analogy is that for any patient who is treated, one does not have a corresponding control. However, in the cricket context, whenever Ω^B occurs, the team that wins the toss is assigned the treatment (under our assumption of rational decision making), while the team that loses the toss is assigned to the control group. Furthermore, this assignment of teams (to the treatment or control groups) is random and independent of team characteristics, since it is made via the coin toss. Indeed, it is striking that at any state $\omega \in \Omega^B$, the winner of the toss is assigned to the treatment group, and has advantage $\lambda(\omega)$ from this assignment, whereas the loser of the toss who is assigned to the control group has an *identical* disadvantage from this assignment. Thus the difference in performance between the teams that win the toss and bat first and those that lose the toss and field first, provides an unbiased estimate of the treatment effect when the treatment is optimal. More formally, we may write, the probability that a team wins conditional on it winning the toss and batting is given by:

$$\Pr[\text{Win}|(\text{WT } \&\text{Bat})) = \frac{\int_{\Omega^B} p(\omega)f(\omega)d\omega + \int_{\Omega^B}[1-q(\omega)]f(\omega)d\omega}{2\Pr(\Omega^B)} \tag{1}$$

This can be simplified to yield:

$$\Pr[\text{Win} \,|\, (\text{WT \& Bat})) = 0.5[1 + \mathbf{E}(\lambda(\omega) \,|\, \Omega^B)] > 0.5. \tag{2}$$

Similarly, we can compute the advantage from fielding first given that fielding is optimal.

$$\Pr[\text{Win} \,|\, (\text{WT \& Field})) = 0.5[1 - \mathbf{E}(\lambda(\omega) \,|\, \Omega^F)] > 0.5. \tag{3}$$

We are now in a position to analyze the advantage from winning the toss upon outcomes in a one-day game. This is simply a weighted average of the mean advantage from batting first when batting is optimal, and the advantage from fielding first when fielding is optimal, as below:

$$\Pr(\text{Win} \,|\, \text{WT}) = 0.5 \left\{ \Pr(\Omega^B)[1 + \mathbf{E}(\lambda(\omega) \,|\, \Omega^B)] + \Pr(\Omega^F)[1 - \mathbf{E}(\lambda(\omega) \,|\, \Omega^F)] \right\}. \tag{4}$$

This expression shows that $\Pr(\text{Win} \,|\, \text{WT}) > 0.5$. This follows from the fact that $\lambda(\omega) > 0$ if $\omega \in \Omega^B$, which implies $\mathbf{E}(\lambda(\omega) \,|\, \Omega^B) > 0$, and $\lambda(\omega) < 0$ if $\omega \in \Omega^B$, which implies $\mathbf{E}(\lambda(\omega) \,|\, \Omega^B) < 0$. Thus we have the intuitive result that winning a toss confers an advantage. Intuitively, the empirical proportion of wins by the team winning the toss is an unbiased estimate of the advantage conferred by winning the toss. Team 1 could be better than team 2, but each is equally likely to win the toss, i.e. the probability of winning the toss is unrelated to the strength of the teams. Thus the difference in win probabilities between the winners of the toss and losers provides an unbiased estimate of the advantage conferred.

To summarize, our empirical tests will be of two kinds. First, we shall examine the consistency of decisions made by the teams, i.e. the no-agreement result. Second, we shall consider the optimality of these decisions in terms of outcomes. Given the simplicity of our hypotheses, we will be able to rely mainly on non-parametric tests of the two hypotheses. It is worth noting that these tests are, in a sense, orthogonal to each other. That is, teams may be behaving consistently without choosing optimally. Conversely, they may be inconsistent, but this inconsistency, while clearly suboptimal, may have no discernible effect on outcomes.

3 Empirical Results

Our data include all one day international matches played between the nine major international teams, since the inception of international one day games in 1970, till July 2003. (In order to ensure competive balance, we have left out involving matches involving the weaker teams). We make a distinction which are played entirely in daylight (day matches) and day-night matches where the team batting second does so at night under floodlights. In day-night matches teams have a strong preference for batting first in daylight, and the team winning the toss bats first 70% of the time, whereas in day matches this proportion is only 40%.

Table 1: Decisions at the Toss, Day Matches[7]

	Pr(Bat | WT)	Pr(Field | LT)	# matches	Pearson	p value
Australia	0.51	0.47	319	0.54	0.46
England	0.34	0.36	277	0.10	0.75
India	0.36	0.35	383	0.09	0.77
New Zealand	0.43	0.41	307	0.16	0.69
Pakistan	0.48	0.35	414	7.96***	0.005
South Africa	0.60	0.52	162	1.13	0.29
Sri Lanka	0.24	0.36	280	5.05**	0.03
West Indies	0.28	0.44	362	9.72***	0.002
Zimbabwe	0.45	0.45	164	0.01	0.93

Table 1 presents our results for day matches. For each of the nine teams, we consider all matches played against any of the other eight opponents. The first column shows the proportion of times that the team bats first on winning the toss, and the second column shows the proportion of time that the team fields first on losing the toss. The penultimate column show the value of the Pearson test statistic for the equality of these two probabilities — this is distributed as a χ^2 with one degree of freedom. The final column shows the probability of getting this value of the test statistic under the null hypothesis. The table shows that for six of the nine teams, the proportions in the first two columns are close to each other, so that the null hypothesis cannot be rejected. However, for three of the nine teams (West Indies, Pakistan and Sri Lanka, whom we shall henceforth refer to as the Gang of Three or G3), the null hypothesis is rejected at 5% level. We find that the West

[7]We systematically use the following abbreviations: WT – Win Toss, LT – Lose Toss. Significance levels: * = 10%, ** = 5%, *** = 1%.

Indies and Sri Lanka have a higher probability of fielding first as compared to their opponents, whereas Pakistan has a higher probability of batting first as compared to its opponents. The fact that consistency is violated in matches involving a specific team, say the West Indies, *does not imply* that the West Indies are making the wrong decision. It does imply, prima facie, that *either* the West Indies *or* their opponents are choosing incorrectly.

It is possible that the rejection results in table 1 for one team (say Pakistan) are being driven by the rejection results of another team in the Gang of Three. To check this in table 2 we consider each of the teams in G3 for whom the null is rejected, but only considering games against the other six teams (i.e. we exclude entirely any matches which between teams from the Gang of Three). We still find that the null hypothesis is rejected at 5% level for Sri Lanka and the West Indies and rejected at 10% level for Pakistan.

Table 2: Day Matches: Against Opponents not from Gang of Three

	Pr(Bat | WT)	Pr(Field | LT)	# matches	Pearson	p value
Pakistan	0.51	0.38	260	4.23**	0.04
Sri Lanka	0.24	0.42	176	6.05**	0.014
West Indies	0.27	0.42	255	6.84***	0.009

To explore this further, we test whether the entire data is consistent with the null. To do this, we consider all 1333 day matches, and let the dependent variable be a dummy variable which equals one if and only if the team that wins the toss bats first. Our controls consist of 32 dummies, one for each pair of teams. In addition, we include eight dummies, where dummy k takes value 1 if and only if team k wins the toss. Under the null, the coefficients on the eight dummies should be zero: an F-test shows that the null is rejected at the 5% level, with a $p-$value of 0.02. This is reported in table 4 (page 13). Thus for day matches, we find a clear rejection of the no agreement result.

Turning to day-night matches in table 3 (page 13), we find that teams have a much stronger preference to bat first — indeed, every team bats first on winning the toss more frequently in day-night matches as compared to day matches. We also find that although there are some differences between the frequency of batting when winning the toss and the frequency of fielding on losing the toss, the Pearson tests show that null hypothesis cannot be rejected at conventional levels of significance for any of the teams. On the one hand, it seems that teams agree that there is usually

Table 3: Decisions at the Toss, Day-Night Matches

	Pr(Bat | WT)	Pr(Field | LT)	# matches	Pearson	p value
Australia	0.78	0.68	211	2.50	0.11
England	0.79	0.79	96	0.0	0.98
India	0.65	0.68	130	0.13	0.72
New Zealand	0.64	0.59	119	0.46	0.50
Pakistan	0.77	0.83	124	0.58	0.45
South Africa	0.61	0.75	116	2.38	0.12
Sri Lanka	0.69	0.72	131	0.20	0.66
West Indies	0.65	0.72	100	0.55	0.46
Zimbabwe	0.83	0.63	45	2.18	0.14

a significant advantage to batting first in day-night matches. On the other hand, the sample sizes are also much smaller (the mean number of day night matches per team is 120 as compared to 274 day matches). Table 4 also shows that the null cannot be rejected in the sample of day-night matches as a whole, by an F test. However, when we combine all matches, day and day-night, the null is rejected, since the dummy variables for the identity of the toss winner are jointly significant.

Table 4: Joint Test of Irrelevance of Identity of Toss Winner

	#matches	F test statistic	p value
Day Matches	1333	2.26	0.02
Day Matches, neutral venues	433	2.27	0.02
Day-Night Matches	538	0.80	0.61
All Matches	1871	2.11	0.03

To summarize, the results are mixed across different classes of matches. In day-night matches, where teams appear to agree on the advantage of batting first in daylight, no-agreement cannot be rejected. In day matches, the null is rejected, with three teams — Pakistan, Sri Lanka and West Indies — choosing differently from their opponents. Overall, the results show that the West Indies demonstrate a clear tendency to field first, as compared to their opponents, in both classes of matches. This is reinforced by the analysis of test matches (Bhaskar, 2004), where the West Indies field first significantly more often than their opponents. This is noteworthy — for a large part of this sample, the West Indies were the strongest team on the international stage. Their dominance was due in large part to a battery of fast bowlers, who were renowned for their pace and hostility, and their ability to intimidate opposing batsmen. Our result suggest that the West Indies favored fielding first as an aggressive tactic, based on their fast bowling strength. The no agreement hypothesis suggests that their opponents should respond to this by fielding first themselves, in order to neutralize the West Indian fast bowling advantage. However, this may have been perceived as a defensive tactic, especially if the opponents did not have a strong fast bowling attack. Thus teams may have overweighted their own strengths, and underweighted the strengths of their opponents. While the overweighting hypothesis appears to be the most plausible explanation for our results, we need to also consider more conventional explanations such as asymmetric information.

Table 5: Win Probabilities, One Day Internationals†

	Pr(Win)	# matches	p value
Win Toss & Bat, Day Matches	0.437	513	0.002
Win Toss & Field, Day Matches	0.503	768	0.57
Toss, Day Matches	0.476	1281	0.047
Win Toss & Bat, Day-Night Matches	0.555	366	0.02
Win Toss & Field, Day-Night Matches	0.493	148	0.47
Win Toss, Day-Night Matches	0.537	514	0.05

† Tied matches and no results excluded.

Let us now turn to the effect of the chosen decision upon outcomes. Table 5 presents win probabilities as a function of the chosen decision. In day-night matches, the team that bats first on winning the toss has a significant advantage, winning on 55.5% of occasions. On the other hand, the advantage of fielding first is not significantly different from zero. In day matches, the team choosing to bat first appears to have a significant disadvantage, winning on only 43.7% of the occasions, while the winning frequency of a team choosing to field first is not significantly different from 50%. Thus in day matches, teams appear to be choosing sub-optimally, by batting first at states where this confers a disadvantage. These results are reflected in our estimates of the advantage of winning the toss — in day-night matches, the team winning the toss wins on 53.7% of occasions, an advantage that is statistically significant at 5% level, while in day matches the team that wins the toss wins only 47.6% of the time, a statistically significant *disadvantage*. We can therefore reject the null that teams are making decisions optimally in day matches, since the estimated treatment effect from batting first is negative.

4 Explanations

We now explore alternative explanations for our findings. These include asymmetric information, the overweighting hypothesis and agency problems due to which the captain of the team may not be concerned only with maximizing the win probability.

4.1 Asymmetric Information and No Agreement

One obvious explanation for violation of the no agreement theorem is asymmetric information. Let us first consider the possibility that a team may have less information about the basic characteristics of opposing players. This is unlikely to be an important factor, since most international teams have a relatively stable core of well established players, whose characteristics are well known. Video footage of international matches is also regularly studied by opponents. For example, in the 2003 world cup tournament, the median player of the nine major teams had made over one hundred international appearances, with very few making less than 30 appearances. However, a team may not be aware of idiosyncratic factors which affect the other team, e.g. it is possible that an individual player may be not fully fit on the day of the match. (Each captain is required to announce the selected players before the toss, so a team will be aware if its opponent leaves out a player, but it is some chance that a player might be chosen to play without being 100% fit). It is easy to see idiosyncratic shocks can explain agreement between team decisions at specific states. However, since idiosyncratic shocks can affect either team and can be in either direction, they cannot explain the empirical finding that some teams bat first significantly less often than their opponents. To see this, we sketch a simple model of idiosyncratic shocks as follows. Assume that after ω is chosen and $\lambda(\omega)$ is observed by both teams, there is a small probability θ that one team (i) receives a shock so that its advantage from batting first is given by $\lambda(\omega) + \varepsilon$, where ε has distribution F. Assume that the distribution of shocks is symmetric across teams, and for simplicity, assume that they affect at most one team. Suppose that $\lambda > 0$ at ω. Then teams may agree, so that team 1 chooses to bat first while 2 chooses to field first, and this event arises with probability $\theta F(-\lambda)$. However, the event where team 1 chooses to field and team 2 chooses to bat also arises with the same probability $\theta F(-\lambda)$, so that at any ω the probability of team 1 batting first still equals to the probability of team 2 batting first.

To explain systematic biases, one needs to invoke the possibility that one team is systematically better informed than the other. This is possible, since the pitch (the natural surface on which the game is played) plays an important role, and the home team is likely to have better information about the nature of the pitch than the visiting team. This is likely to be true for venues in the home country which are not as well known or internationally established. The following anecdote from the autobiography of Mike Atherton, former captain of England, is illustrative:

> ... at St. Vincent I made an error of judgement at the toss, putting the West Indies in. We went down to a then record defeat for England in one-day internationals. The day before that game I had been, literally, sitting on the dock of the bay watching the time go by, and pondering the team for the next day. A Rastafarian smoking a huge spliff came by and we got chatting. 'Man,' he said, 'you always got to bat first in St. Vincent and then bowl second when the tide comes in.' The pitch the next day look mottled and uneven and I looked at it uncertainly. Geoff Boycott was also on the wicket and I asked his opinion. 'I think you've got to bowl first,' he said, 'just to see how bad it is before you bat.' In fact it was very good and the West Indies plundered 313, and then, when the tide came in, it was very bad and we were skittled for 148. I learned my lesson. When it comes to pitches you had never seen before, local knowledge, rather than the Great Yorkshireman's, was eminently preferable. (Atherton, 2002, p.85).

We now set out a simple model of asymmetric information. Assume that, as in Fig. 1, the set of states Ω is a compact interval, arranged so that the batting advantage λ is a decreasing function of ω. Let ω be distributed with a density f on the interval Ω. The information of player $i, i \in \{1, 2\}$, is represented by an information partition Ω_i of Ω. Thus if state ω is realized, and if ω belongs to the k-th element of i's information partition, Ω_i^k, then player i is informed only of the fact that $\omega \in \Omega_i^k$. Suppose that team 1 is informed that $\omega \in \Omega_1^k$. The probability it assigns to winning from batting first is given by:

$$p_1^k = \int_{\Omega_1^k} p(\omega) f(\omega) d\omega. \tag{5}$$

While the probability assigned by team 1 to winning from fielding first is given by:

$$q_1^k = \int_{\Omega_1^k} q(\omega) f(\omega) d\omega. \tag{6}$$

Thus it is optimal for team 1 to bat first if $p_1^k > q_1^k$, and to field first otherwise. Equivalently, it is optimal to bat first if $\mathbf{E}(\lambda(\omega) \,|\, \Omega_1^k) > 0$, and to field first if $\mathbf{E}(\lambda(\omega) \,|\, \Omega_1^k) \leq 0$. Similarly, for team 2, it is optimal to bat first at $\omega \in \Omega_2^k$ if $\mathbf{E}(\lambda(\omega) \,|\, \Omega_2^k) > 0$, and to field first if $\mathbf{E}(\lambda(\omega) \,|\, \Omega_2^k) \leq 0$.

Let Ω_{12} be the meet of the two information partitions, Ω_1 and Ω_2, i.e. the coarsest partition that is finer than both Ω_1 and Ω_2. Figure 2, on page 18, depicts a simple example of the information partitions of the two players. The first line in this figure depicts the set of states, and the sets Ω^B and Ω^F. The second line depicts player 1's information partition, consisting of three sets, which are labelled in terms of team 1's optimal decision — team 1 will choose to bat at its first two information sets, and field at the third. The third line depicts team 2's information partition, with the sets labelled in terms of team 2's optimal decision. Finally, the last line depicts Ω_{12}, the meet of the two information partitions, with each element being labelled in terms of the optimal decisions of team 1 and team 2 respectively. We see that if $\omega \in \Omega_1^2 \cap \Omega_2^2$, i.e. the third set labelled BF, then team 1 will choose to bat while team 2 chooses to field, so that there is agreement on this subset of the state space.

To investigate whether asymmetric information about pitches can explain no agreement, we first consider one day matches at neutral venues, where superior information is unlikely to be a factor. Table 6 reports our results for day matches involving Pakistan, Sri Lanka and the West Indies, where we had found violations of no agreement. We find that no agreement is rejected for neutral venues for two of the three teams (Pakistan and West Indies). Table 4 tests the no agreement result for all teams, utilizing only neutral venues, and finds that this is decisively rejected.

Table 6: Day Matches, Neutral Venues

	Pr(Bat | win T)	Pr(Field | Lose T)	#matches	Pearson	p value
Pakistan	0.54	0.33	177	7.90***	0.005
Sri Lanka	0.31	0.41	112	1.22	0.27
West Indies	0.21	0.46	121	8.12***	0.004

For matches played at non-neutral venues, where one team may be better in-

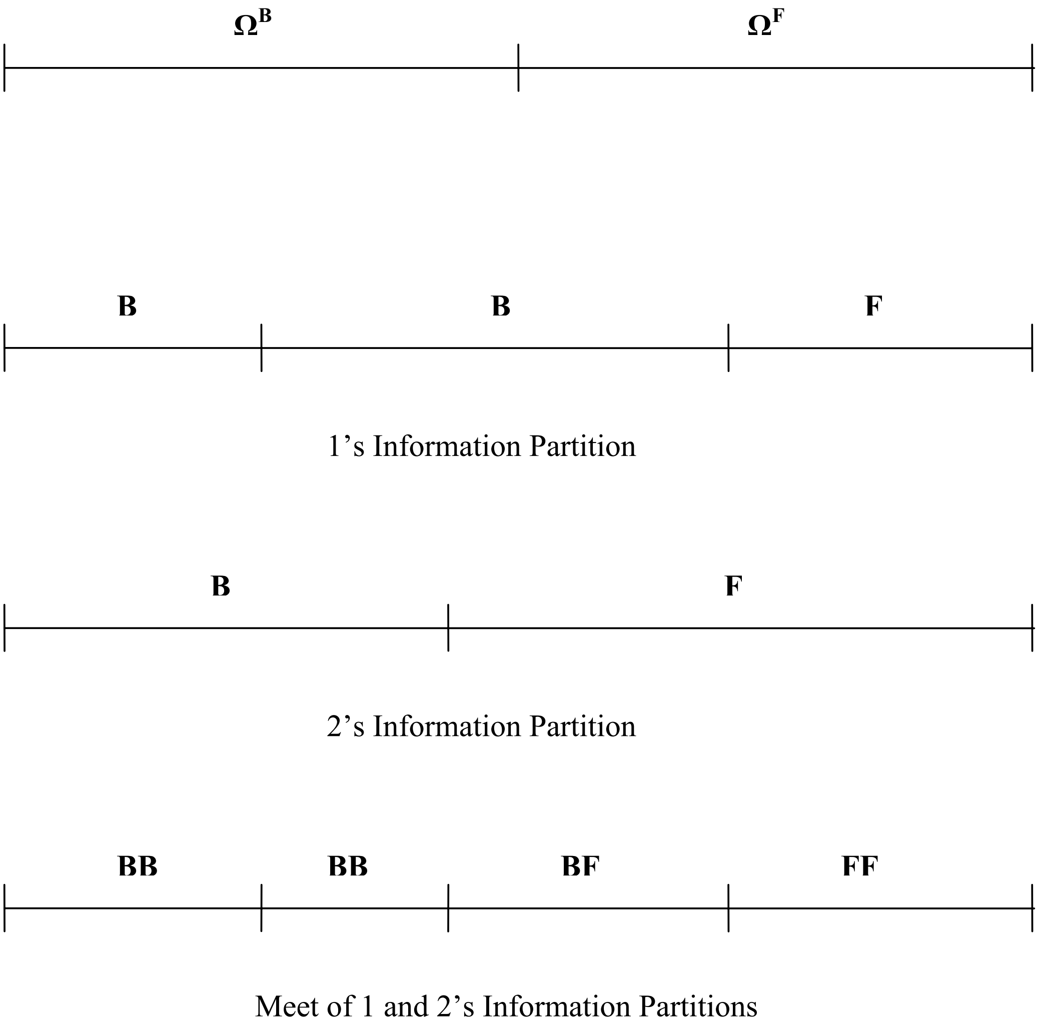

Fig. 2: Information Partitions

formed, asymmetric information can obviously be invoked as a catch-all explanation. Let us however impose further structure, to see the likely pattern of biases when the home team is better informed than the away team. Assume that the home team, team 1, observes ω. Assume that with some probability π the away team (team 2) also observes ω, while with probability $1-\pi$ team 2 has no information. When team 2 has no information, its optimal choice is given by determined by the average value of λ, i.e. by:

$$\mathbf{E}(\lambda) = \Pr(\Omega^B)\mathbf{E}(\lambda(\omega)\,|\,\Omega^B) + \Pr(\Omega^F)\mathbf{E}(\lambda(\omega)\,|\,\Omega^F) \tag{7}$$

Let us suppose, for the moment, that $\mathbf{E}(\lambda(\omega)\,|\,\Omega^B) \approx -\mathbf{E}(\lambda(\omega)\,|\,\Omega^F)$, i.e. the average advantage from batting first when batting is optimal approximately equals the average advantage from fielding first when fielding is optimal. In this case, when uninformed, team 2 will choose to match the expected decision of team 1. Thus team 2 will always bat first if team 1 bats first more often, and will always field first if team 1 fields first more often. So if the informed team bats first more often, i.e. $\Pr(\Omega^F) > \Pr(\Omega^B)$, the probability that team 2 bats first is given by $\pi\Pr(\Omega^B)$. Thus if the informed team is more likely to field first, the uninformed team fields first *even more often*. The informed team benefits from its superior information at states where it is optimal to bat first. This conclusion fits very well the incident related by Atherton, where England made the "wrong" choice by deciding to field first against a team (West Indies) which chooses to field first in most situations.

We now explore whether the differences in decisions across home and away venues is consistent with the biases implied by the above model of asymmetric information. In table 7 (page 20) we consider the three teams where no agreement fails (Pakistan, Sri Lanka and West Indies), and see how their decisions differ from their opponents on home and away venues.

The table reports the batting frequencies of the home team and away teams, and the third column reports whether the bias is in the right direction (i.e. consistent with the home team being better informed) or not. The two teams for whom no-agreement is violated at home venues are Sri Lanka and West Indies. Sri Lanka chose to bat first only 8% of the time when playing at home. If Sri Lanka had better information, we would expect their opponents to respond to this by choosing to bat first even more infrequently. Instead we find that they bat first substantially more often than Sri Lanka, with a discrepancy on 29% of the occasions. The magnitudes

Table 7: Pr(Bat | Win Toss), Day Matches

	Home Team	Away Team	Bias	#matches	Pearson†	p value
Pak. Home	0.54	0.33	WRONG	102	0.25	0.62
Pak. Away	0.36	0.43	WRONG	125	0.59	0.44
SL home	0.09	0.40	WRONG	62	7.92***	0.005
SL away	0.31	0.26	RIGHT	94	NA‡	NA
WI home	0.28	0.50	WRONG	105	5.40**	0.02
WI away	0.36	0.35	RIGHT	125	NA	NA

† Pearson test statistic computed when bias has wrong sign, for the null with bias=0.
‡ NA: Not Applicable.

involved also imply that the approximation $\mathbf{E}(\lambda(\omega)|\Omega^B) \approx -\mathbf{E}(\lambda(\omega)|\Omega^F)$ used for this argument is quite loose, since it suffices that $\mathbf{E}(\lambda|\Omega^B) < -11\mathbf{E}(\lambda|\Omega^F)$ for our conclusions to hold. A similar argument applies to the West Indies — although they bat first only 28% of the time at home, their opponents respond by batting first substantially more often, at 50%. This reinforces our general conclusion, that asymmetric information can explain specific departures from no-agreement (such as that referred to by Atherton), but not the systematic departures we find in the data.[8]

4.2 Asymmetric Information and Treatment Effects

Asymmetric information may also bias the estimates of treatment effects, as reported in table 5. Let Ω_i^B be the set of states where i finds it optimal to bat, and Ω_i^F be the complement. We have seen that Ω_1^B can differ from Ω_2^B under asymmetric information. This can bias the estimates of the treatment effect, if the ability of a team is correlated with its propensity to bat first. For example, the West Indies have a lower probability of choosing to bat first, and have also been one of the strongest teams. This would tend to bias down the estimates of the probability of winning, conditional upon choosing to bat first. To see this, let z index the relative abilities

[8] As Meg Meyer has pointed out, one may invoke specific forms of asymmetric information in order to generate biases in decisions of the uninformed away team which are more consistent with the data. Let $\Pr(\Omega^B) < 0.5$, and suppose that the away team's information partition consists of two elements, $\{\Omega_2^1, \Omega_2^2\}$ with Ω_2^2 a strict subset of Ω^F. If $\Pr(\Omega^B) > 0.5\Pr(\Omega_2^1)$, the away team will choose to bat at Ω_2^1 and will therefore bat more often than the home team (assuming $\mathbf{E}(\lambda|\Omega^B) \approx -\mathbf{E}(\lambda|\Omega^F \cap \Omega_2^1)$). However, the difference in their batting probabilities must be less than $\Pr(\Omega^B)$. This special information structure may conceivably explain the batting frequency of away teams in the West Indies (0.50 as compared to 0.28) but not in Sri Lanka (0.40 compared to 0.09).

of the two teams, and let:

$$p(\omega, z) = \frac{1}{2} + \frac{\lambda(\omega)}{2} + z \tag{8}$$

$$q(\omega, z) = \frac{1}{2} - \frac{\lambda(\omega)}{2} + z. \tag{9}$$

Let $\alpha = \frac{\Pr(\Omega_1^B)}{\Pr(\Omega_1^B)+\Pr(\Omega_2^B)}$, the proportion of the time that the team choosing to bat first is team 1. The probability of winning, conditional on a team choosing to bat and conditional on z, is given by:

$$\Pr[\text{Win} \mid \text{WT \&Bat}) = 0.5 + (2\alpha - 1)z + 0.5 \left[\alpha \mathbf{E}(\lambda(\omega) \mid \Omega_1^B) + (1-\alpha)\mathbf{E}(\lambda(\omega) \mid \Omega_2^B)\right]. \tag{10}$$

Now since $\mathbf{E}(\lambda(\omega) \mid \Omega_i^k) \geq 0$ at every information set where team i chooses to bat first, the term in square brackets is positive. This term can still be interpreted as the average treatment effect when the treatment is optimal, with the caveat that the two teams do not always agree at all states that the treatment is optimal. However, if $\alpha \neq 0.5$, the probability of winning also depends upon relative ability. This implies that the winning probabilities in table 5 are not unbiased estimates of treatment effects, since ability may be correlated with the propensity to bat first. Similarly, the effect of choosing of field first is given by

$$\Pr[\text{Win} \mid \text{WT \& Field}) = 0.5 + (2\beta - 1)z - 0.5 \left[\beta \mathbf{E}(\lambda(\omega) \mid \Omega_1^F) + (1-\beta)\mathbf{E}(\lambda(\omega) \mid \Omega_2^F)\right], \tag{11}$$

where $\beta = \dfrac{\Pr(\Omega_1^F)}{\Pr(\Omega_1^F) + \Pr(\Omega_2^F)}$. Here the term in square brackets is negative, which implies that the once one controls for ability, the effect of fielding first when choosing to do so must be positive. It can be verified that the ability effect has the opposite sign as compared to (10).

Note however that asymmetric information does not bias the estimates of the toss advantage, since this is exogenous. The advantage of winning the toss is weighted average of the two probabilities:

$$\Pr[\text{Win} \mid \text{WT}) = 0.5 \left\{ 1 + \begin{array}{c} \Pr(\Omega_1^B)\mathbf{E}(\lambda(\omega) \mid \Omega_1^B) + \Pr(\Omega_2^B)\mathbf{E}(\lambda(\omega) \mid \Omega_2^B) \\ -\Pr(\Omega_1^F)\mathbf{E}(\lambda(\omega) \mid \Omega_1^F) - \Pr(\Omega_2^F)\mathbf{E}(\lambda(\omega) \mid \Omega_2^F) \end{array} \right\}. \tag{12}$$

Note that the term in z cancels out, so that ability will not bias our estimates.

However, it may still be useful to control for ability in order to improve the efficiency of our estimates of the advantage of winning the toss.

We must therefore control for ability in order to provide unbiased estimates of the treatment effect. Let i and j index the two teams, and let us describe outcomes from the point of view of team i. The probability that i wins given that i wins the toss and chooses to bat is given by:

$$\Pr(i \text{ win} \,|\, \text{WT \& Bat}) = 0.5 + z_{ij} + 0.5\mathbf{E}(\lambda(\omega) \,|\, \Omega_i^B). \tag{13}$$

The probability that i wins given that i loses the toss and fields, is given by:

$$\Pr(i \text{ win} \,|\, \text{LT \& Field}) = 0.5 + z_{ij} - 0.5\mathbf{E}(\lambda(\omega) \,|\, \Omega_j^B). \tag{14}$$

Similarly, we have:

$$\Pr(i \text{ win} \,|\, \text{WT \& Field}) = 0.5 + z_{ij} - 0.5\mathbf{E}(\lambda(\omega) \,|\, \Omega_i^F) \tag{15}$$

$$\Pr(i \text{ win} \,|\, \text{LT \& Bat}) = 0.5 + z_{ij} + 0.5\mathbf{E}(\lambda(\omega) \,|\, \Omega_j^F). \tag{16}$$

Thus we may regress the outcome for this pair of teams (of fixed relative ability z_{ij}) on four dummy variables, WT&Bat, LT&Field, WT&Field, LT&Bat, (WT&Bat equals one if and only if team i wins the toss and bats, and the other variables are defined analogously, and we exclude the constant term). The difference between the coefficients on WT&Bat and LT&Field is an unbiased estimate of $0.5[\mathbf{E}(\lambda(\omega) \,|\, \Omega_i^B) + \mathbf{E}(\lambda(\omega) \,|\, \Omega_j^B)]$, i.e. of the average advantage from batting first when batting is optimal. Since there are only a few matches where relative ability may be assumed to be constant, it is preferable to do this estimation on the entire data set. Specifically, we estimate a linear probability model, with dummies for each pair of teams, (i, j). We also distinguish between home and away matches — the control for venue of play is a categorical variable which takes value 1 if the game is played at home (i.e. in the country of team i), value -1 if the game is played away (i.e. in the country of team j) and zero if played at a neutral venue. Finally, we introduce a dummy variable corresponding to each of the four situations (WT&Bat, etc.) listed above. Thus the treatment effect of batting first when batting is optimal (the coefficient on Toss & Bat in table 8) is given by the difference in coefficients between the dummy for winning the toss and batting that for losing the toss and fielding.[9] Similarly,

[9]From the theoretical model, this should equal a weighted average of $\mathbf{E}(\lambda(\omega) \,|\, \Omega_j^B)$ across all

the effect of fielding first when fielding is optimal is given by the difference in coefficients between the dummy for winning the toss and fielding that for losing the toss and batting. The estimates reported in table 8 are very similar to the raw figures in table 5. For example, the disadvantage when choosing to bat first in day-night matches is 0.126 from table 5 (this is computed as twice the probability of winning minus 1) , while the estimate with ability controls is 0.123. Similarly, the advantage when choosing to bat first in day matches is 0.120 from table 5, while with ability controls this advantage is 0.111. Thus our basic conclusions, that teams had a significant advantage from choosing to bat first in day-night matches, and a significant disadvantage from choosing to bat first in day matches, is unaltered by allowing for controls for ability. Indeed, we have used a number of different specifications to control for ability (including allowing team abilities to be different across periods), and the results are not altered.

Table 8: Treatment Effects by Type of One Day Match†

	Day	Day excl. G3‡	Day	Day-Night	Day-Night
Win Toss & Bat	−0.123 (3.0)	−0.194 (3.1)		0.111 (2.2)	
Win Toss & Field	0.002 (0.1)	0.067 (1.1)		−0.021 (0.7)	
Win Toss			−0.024 (1.8)		−0.035 (1.6)
sample size	1292	445	1292	522	522

† Excluding matches without a result.

‡ Day matches not involving Pakistan, Sri Lanka or West Indies.

Table 8 confirms that there is a significant advantage to the team winning the toss when it chooses to bat first, a phenomenon which has recently been noted by cricket commentators. In the recent world cup held in South Africa, commentators remarked that the team batting second found it significantly more difficult to bat, especially when dew increased the moisture in the pitch. Many suggested that day-night matches were an unfair contest, of the “win the toss win the game variety”. Day-night games are however popular with spectators, and financial considerations dictate that they will continue. One solution would be to handicap the team batting first appropriately, say by allowing them somewhat fewer balls to make their runs in. Since the advantage to the team batting first is not uniform, but heterogenous,

teams j, where the weight for team j is the fraction of times that team j bats first on winning the toss as a proportion of the number of times that any team winning the toss bats first.

the handicap should be state dependent. One solution is to adapt the classical solution to the cake-cutting problem, ala Steinhaus — e.g. the team losing the toss chooses the level of the handicap (i.e. the number of balls less that the team batting first would get), while the team winning the toss chooses whether the bat first or to field first given this handicap. If preferences are heterogeneous, the divider has a strategic advantage in the cake cutting problem (see, for example, van Damme, 1991). However, since the choice of whether to bat or field is essentially a choice over probability distributions, the preferences of the two teams are identical in this case, and this is a fair protocol.

Overall, our results suggest that teams do not make decisions very well when they win the toss. In day-night matches, where cricket commentators recognize the advantage from batting first, teams tend to bat first (over 70% of the time) and appear to derive a significant advantage when they choose to bat. In one day internationals which are played in the day, teams which choose to bat first seem to have a significant *disadvantage* from this choice. This is a robust finding, which survives many different controls to proxy the relative abilities of teams.

4.3 Overweighting strength

We have argued that asymmetric information does not provide a convincing explanation for the failure of no-agreement in day matches. Instead, it seems that teams overweight their own strengths (or weaknesses), and underweight the strengths or weaknesses of their opponents. This is reinforced by the finding that one team in particular — the West Indies — chose to field first more often than their opponents in *all* forms of international cricket since the 1970s (see Bhaskar (2004) for an analysis of decisions in test matches). The West Indies were the undisputed champions of the world for a large part of this period, until the mid 1990s. Their dominance was based on a hostile fast bowling attack, which was unparalleled in cricketing history, and capable of intimidating their opponents — unlike baseball, it is a legitimate cricket tactic for a bowler to hit the body of the batsman with the ball. Indeed, the West Indies would usually play with four fast bowlers, and without any spin bowler at all. Thus the West Indies would often choose to field first, allowing their fast bowlers to exploit the early moisture on the pitch. This suggests that it would be optimal for their opponents to first , in order to deny the West Indies this advantage. Nevertheless, we find that the opponents often batted first, since they did not have a fast bowling attack as capable as that of the West Indies. In other words, faced with the aggressive tendency of the West Indies to field first, their opponents did not respond defensively by fielding first, but instead chose to bat first on many occasions. This overweighting hypothesis has some commonalities the winner's curse, where agents overweight their own information.

Let us now consider the effect of overweighting on treatment effects. Assume that there is no asymmetric information, but suppose that team 1 has a strong fast bowling attack, and overweights this in decisions. Specifically, the threshold value of λ at which it chooses to bat is not 0, but some positive number λ_1. Thus Ω_1^B is the set of states with $\lambda(\omega) \geq \lambda_1$. Similarly, if team 2 also overweights its strength and bats more often, it may choose a threshold $\lambda_2 < 0$. In this case, the expected difference between the coefficients on WT&Bat and LT&Field is still given by $0.5[\mathbf{E}(\lambda(\omega)|\Omega_1^B)+ \mathbf{E}(\lambda(\omega)|\Omega_2^B)]$,although Ω_1^B and Ω_2^B have a different interpretation as compared to the asymmetric information case. Now in this specific example, $\mathbf{E}(\lambda(\omega)|\Omega_1^B) > \mathbf{E}(\lambda(\omega)|\Omega^B) > 0$, since team 1 only bats at states which are most favorable for batting first. However, $\mathbf{E}(\lambda(\omega)|\Omega_2^B)$ could possibly be negative, since team 2 also bats at some states with $\lambda < 0$. Thus the net effect of overweighting upon the estimated treatment effect is ambiguous. Evidence of overweighting does not, in itself, explain why the estimated effect of batting first could be negative, as we find in the case of one day matches played in the day.

To see whether overweighting explains anomalous treatment effects, we now drop those teams where no-agreement is violated. That is, in day matches, we exclude games where any team from the Gang of Three plays. These results are reported in table 8, column 2. The negative treatment effect from choosing to bat is substantially larger — almost -19% as compared with -12% in column 1 of this table. Removing the teams with whom overweighting is important does not seem to eliminate the estimated negative treatment effect.

4.4 Agency Problems

A second aspect in which decision making is does not seem to be optimal is in terms of the estimated treatment effects. In summary, the estimated advantage from batting first is positive in one-day day-night matches. However, in one day matches played in the day, the teams which choose to bat first seem to be choosing suboptimally. We now see why the historical background and the way in which the decision maker (the team captain) is evaluated may result in his having somewhat different interests than simply maximizing the probability of winning, thus resulting in an agency problem.

Traditions play an important role in cricket, and test cricket was the only form of the game at international level, till 1970. Test match pitches used to be left uncovered when play was not in session, hastening their deterioration over the five days of play. This meant a recognizable advantage to batting first [10] and in test matches before 1975, captains chose to bat on 87% of occasions. This had a significant positive effect on their winning probability — Bhaskar (2004) finds that the team choosing to bat first wins 55% of the time in matches with a result. In more recent times, the practice of covering pitches when play is not in session has reduced this advantage significantly. The technology of making pitches has also improved, increasing their durability, and making batting last less difficult. In one day matches, the scope for deterioration is more limited. Finally, in one day matches (as opposed to test matches), the team batting second has the advantage of knowing precisely what score needs to be made to secure victory — the dynamic programming analysis of Clarke (1999) and Preston and Thomas (2000) find this to be quantitatively significant.

We argue that cricket was faced with a new innovation — one day matches played in the day — where the relative gain from fielding first was high compared to test cricket. However, the data shows that captains have not learnt very well to make decisions in this new environment.[11] One explanation is as follows: the captain's decision is evaluated by cricket commentators (usually former cricketers), and in the final analysis, by the selectors of the team, who are usually also former cricketers. These evaluators may have outdated information, with a consequent bias against batting first. This bias appears to exist — as the former England captain Brearley writes, "it is irrationally felt to be more of a gamble to put the other side in (to bat) . . . decisions to bat first, even when they have predictably catastrophic consequences, are rarely held against one" (Brearley, 1985, p. 116). Thus a variant on the management adage "no one ever got fired for buying IBM", may well partially explain the persistence of suboptimal decisions.[12] Given the relatively short time horizon over which captains are evaluated, captains who choose to bat when there is a small advantage to fielding first may well survive longer than those who choose optimally.

[10] The legendary W.G. Grace once said: "When you win the toss — bat. If you are in doubt, think about it — then bat. If you have serious doubts, consult a colleague — then bat."

[11] Nor does there appear to be a significant improvement in performance in more recent matches, as would be the case if there was learnng.

[12] This also appears to be related to Romer's (2003) finding, that the safer option tends to be chosen in American football.

5 Conclusions

While tests of decision theory have examined the consistency of decisions of a single decision maker with stable preferences, the innovation of our study has been the examination of the consistency of decision makers whose interests are opposed. For this purpose, we are able to exploit "randomized trials" which are inherent in the rules of the game. We find significant violations of consistency and argue that these violations are best explained by a tendency for teams to overweight their own strengths, and underweight those of their opponents. Our randomized trials also allow us to identify average treatment effects, conditional on the treatment being optimal. Here again we find some evidence that choices are not made optimally.

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