Nobody's Innocent – The Role of Customers in the Doping Dilemma*

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Abstract

Customers who boycott an organization after some scandal may actually exacerbate the fraud problem they would like to prevent. This conclusion is derived from a game-theoretic model that introduces a third player into the standard inspection game. Focusing on the example of doping in professional sports, we observe that doping is prevalent in equilibrium because customers undermine an organizer's incentives to inspect the athletes. Establishing transparency about doping tests is necessary but not sufficient to overcome this dilemma. Our analysis has practical implications for the design of anti-doping policies, as well as for other situations of fraudulent activities.

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1 Introduction

When fraudulent activities are detected in some organization, the customers have to make a decision. Either they continue the relationship with this organization or they boycott it. Behaving in the latter way, i.e. reacting to scandals with a withdrawal of support, can be expected to reduce the extent of fraudulent activities (since the potential loss increases). As we will show in this paper, however, the effect might just go into the opposite direction: Critical customers who withdraw support after a scandal unintendedly trigger fraudulent activities. This conclusion follows from a game-theoretic model which extends the standard inspection game by an additional player.[1] We carefully analyze and discuss this model focusing on the example of doping in professional sports.

Sport events, such as the Olympic Games, have grown to a size of substantial economic importance. Thereby the use of performance-enhancing drugs (doping) is considered as a risk for the sports industry. There are at least three reasons why it is socially desirable to reduce the extent of doping (cf. Preston and Szymanski, 2003). First, as it is well known, the use of performance-enhancing drugs can lead to serious health problems for the athletes. Second, athletes often serve as role models.[2] Thus, a doped athlete is neither in the best interest of parents nor would she give the right image for a sponsoring company. Closely linked to that point is the third argument: An important character of sport is that it becomes uninteresting if athletes systematically violate the rules.[3] Given these arguments, it is not surprising that even the United Nations and the European Commission (EC) are interested in anti-doping policies.[4] The most important scientific questions on doping concern (i) the actual extent of doping – whether the use of performance-enhancing drugs is an exceptional practice of some delinquent athletes or a common practice – and they concern (ii) instruments to reduce the extent of doping.

Despite the rich set of anecdotal evidence, empirical studies about doping are rare. It seems very hard to collect data of high quality. Those few studies that try to assess the extent of doping empirically, make estimations that often strongly exceed the public perception

(Pitsch et al., 2007; Striegel et al., 2010; Pitsch and Emrich, 2012).[5] Theoretical approaches to the doping issue have acknowledged that decisions to dope are not independent of decisions of other actors such as other athletes or control agencies. Game theory provides tools to analyze such situations of strategic interaction. The primary focus is thereby given to the interaction among athletes. Since the pioneer work of Breivik (1992), this interaction is often modeled as a prisoner's dilemma, where to dope is the dominant strategy (cf. Bird and Wagner, 1997; Haugen, 2004; Eber, 2008).[6] Extending this approach, game theory is also used to analyze the interaction between athletes and an organization which decides upon conducting doping tests. This is usually modeled as an inspection game (Berentsen et al., 2008; Kirstein, 2012).[7] In an inspection game, there is no pure strategy Nash equilibrium because athletes want to dope without being detected, while the control organization tries to detect doping without testing clean athletes. Thus, mixed strategy equilibria, respectively, perfect Bayesian equilibria are used, which predict an intermediate level of doping.

We build on the previous game-theoretic work on doping but take the analysis one level further by introducing *customers* as an additional player into the game. Customers are highly important because they finally make professional sports economically viable. Consider a sports event from which customers turn away their interest. This event does not only suffer of less ticket and merchandise revenues, it will also become less attractive for media companies who report from the event and for companies who sponsor the event. In Appendix A, we present several pieces of evidence for the importance of customers. In particular, the recent history of the Tour de France, the world's most famous cycling race, suggests that the reaction to the disclosures of systematic doping practices is the *withdrawal of support* from several stakeholders. For many other disciplines and events, this scenario has not happened, but it seems to be always present as a *threat*. Importantly, already the threat of withdrawing support is sufficient to significantly affect the incentives to dope, as we show in this paper. Despite their essential role, previous studies (to the best of our knowledge) have

not included customers as a player in an inspection game. This paper closes this gap and explicitly analyzes the *role of customers* for the incentives to dope (respectively to cheat in a different context).

In our model, customers support a sports event as long as there is no doping scandal. After a scandal we assume that customers would withdraw their support (and contrast this case from the benchmark case of non-critical customers who always keep supporting). One might conjecture that the behavior of critical customers induces incentives for organizers and athletes to avoid doping since this increases the costs of doping for both athletes and organizers. However, our analysis reveals that the opposite is true: Under mild assumptions, the unique outcome of the game is that athletes dope, while organizers make insufficient effort to test them. Because our assumptions are very parsimonious, this result is robust against many changes in the specification of utility. The intuition is simply that customers who can withdraw their support constitute a threat to the organizers such that they avoid uncovering (the full extent of) doping.

We then investigate how to change the institutions in order to support a doping-free equilibrium. It turns out that establishing transparency serves this purpose: If customers can observe whether there were serious doping tests, even if they turned out to be negative, then there is a doping-free equilibrium. However, this equilibrium is not unique – there is still an equilibrium involving doping. To rule out all doping equilibria it would be necessary to have a different kind of customer behavior, not only different institutions. We discuss the real world predictions of this model and the practical implications of its results for currently debated anti-doping policies.

The remainder of the paper is organized as follows: Section 2 presents the model. Section 3 establishes the main results, thereby characterizing the doping equilibrium. Section 4 studies a change of institutions that admits a doping-free equilibrium. In Section 5, we conclude.

2 Model

Considering benefits from professional sports, there is a large set of stakeholders: sports associations, team sponsors, event organizers, event sponsors, media, spectators, anti-doping agencies, doctors, politicians, etc. In our model, we restrict attention to three types of players: Athletes, Organizers, and Customers. Athletes can decide between doping and staying clean, whereas doping is defined as the use of illicit substances or methods.[8]

In our model, Organizers represent those actors who decide whether to conduct serious doping tests or not. Thus, testing stands for systematically attempting to detect and punish doped Athletes. An Organizer in that sense is the world anti-doping agency WADA.[9] In several disciplines, the national anti-doping agencies (NADAs) have a major role in organizing doping tests of their athletes. In other disciplines, the sports associations or the event organizers are the key players in organizing systematic doping tests.[10] Consequently, Organizers in our model represent anti-doping agencies, as well as organizers of sports events and sports associations. Indeed, anti-doping agencies are not independent of these organizations (Eber, 2002; Preston and Szymanski, 2003); and with respect to the decision we study here, they have similar interests or they can simply not conduct serious tests without the collaboration of the event organizers or the sports associations.[11]

Customers can decide upon staying a supporter or to withdraw support, e.g. not to continue watching an event on TV, not to further buy merchandise products, or to quit a membership in a club of supporters. Besides spectators, we can also subsume sponsors and the media (who broadcast or report about the sport events) under the term Customers. A withdrawal of each of these three actors can trigger the withdrawal of the two others. Sport events cannot survive without sponsors, withdrawal of the media restricts the access of the customers, and finally sport is only attractive for sponsors as long as there are customers. To make the arguments as clear as possible we focus on one representative customer and we also study only one representative organizer and one representative athlete (such that the strategic interaction between athletes is only presented in a highly reduced form). The

extension to multiple players of a type would not qualitatively affect the results, but it would affect the ease of illustration. Therefore, we interpret the behavior of a representative player as the behavior of the Athletes, the Organizers, and the Customers (in plural).

The timing of the players' actions is as illustrated in Figure 1. First, Athletes decide on doping, then Organizers decide on testing, and finally Customers decide upon staying. The information set of the Organizers indicates that they do not observe the action of Athletes. Thus, the moves of Athletes and Organizers can also be considered as being simultaneously. In our model, testing means that a doped Athlete is detected and punished. If the history in this first stage is $(Dope, Test)$ we call it a "scandal." All other histories, i.e. $(Dope, Notest)$, $(Clean, Test)$, $(Clean, Notest)$, are no scandal. Since doping tests and their outcomes are not transparent to the public, Customers cannot distinguish between the three possible histories if there was no scandal.[12] This is captured by the information set consisting of three nodes. As Figure 1 shows, this game has eight potential outcomes, which we label in the following way: d-t-s, d-t-l, d-n-s, d-n-l and c-t-s, c-t-l, c-n-s, c-n-l as also illustrated in Figure 1. The depicted payoff vectors are in the order Athletes, Organizers, Customers and only present one possible example.[13]

While Athletes and Organizers have two strategies each $\{Dope, Clean\}$, respectively $\{Test, Notest\}$, Customers can choose between two actions in two information sets, which yields four strategies. We denote them by $\{SS, SL, LS, LL\}$, where, for instance, LS stands for action $Leave$ in the first information set (after a scandal) and action $Stay$ in the second information set (after no scandal). The wording 'leave' is a bit strong in the sense that it is not necessary that Customer support is fully lost with this action, but only that it becomes significantly smaller compared with the action $Stay$.

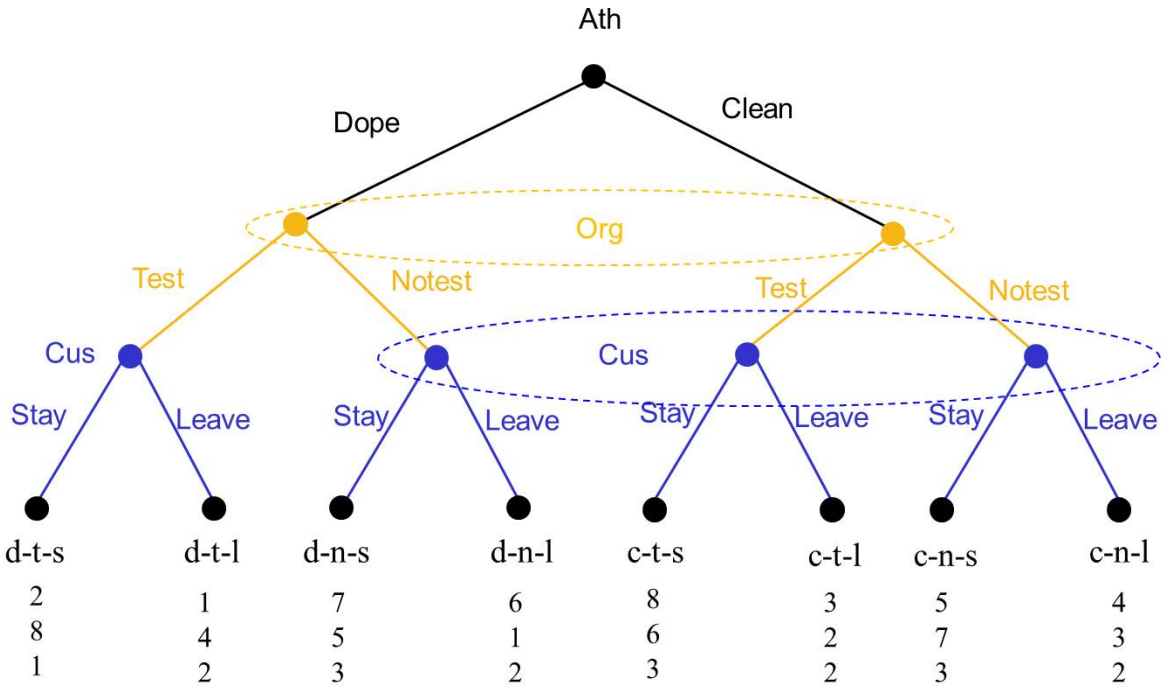

Figure 1: Structure of the game and an example for payoffs.

3 The Doping Equilibrium

In our analysis, we focus on pure strategies and employ the notion of subgame perfect Nash equilibrium (SPNE). When the extension to behavioral strategies, where agents can continuously mix between actions, and the refinement of perfect Bayesian equilibrium (PBE) yield different results, we make this explicit. We will introduce assumptions on the players' preferences step-by-step to clarify that mild assumptions are sufficient for some results (equilibrium), while stronger assumptions are needed for others (inefficiency).

3.1 Existence of a Doping Equilibrium

We are most interested in the kind of Customers who withdraw their support after a scandal but not otherwise. This idea is covered by Assumption A1 which makes mild assumptions on the preferences of all the players.

Assumption 1. *For the players' preferences we assume the following:*

Ath: *d-n-s* $\succ^{Ath}$ *c-n-s, i.e. Athletes prefer to dope if not tested; and c-t-s* $\succ^{Ath}$ *d-t-l, i.e. Athletes prefer to be clean and tested, while Customers stay, over being doped and tested, while Customers leave.*

Org: *d-n-s* $\succ^{Org}$ *d-t-l, i.e. a scandal combined with the loss of Customers is worse for the Organizers than undetected doping where Customers stay; and c-t-s* $\succ^{Org}$ *c-n-l, i.e. testing clean Athletes with Customers support is better for the Organizers than not testing clean Athletes when Customers leave.*

Cus: *d-t-l* $\succ^{Cus}$ *d-t-s, i.e. Customers prefer to withdraw support after a scandal; and d-n-s* $\succ^{Cus}$ *d-n-l, c-t-s* $\succ^{Cus}$ *c-t-l, and c-n-s* $\succ^{Cus}$ *c-n-l, i.e. Customers prefer to stay if there is no scandal.*

The Assumptions A1 are easy to justify. The assumption that Athletes dope if there are no tests follows from the standard assumption in the literature that the benefits of doping exceed the costs, even if there were tests (e.g. Maennig, 2002).[14] Organizers might existentially depend on Customers' support such that they would probably prefer any outcome where Customers stay (i.e. d-t-s, d-n-s, c-t-s, and c-n-s) over any outcome where support is withdrawn (i.e. d-t-l, d-n-l, c-t-l, and c-n-l). This also means that testing is not too expensive in the sense that the withdrawal of customer support is worse than conducting tests. This assumption needs not be satisfied for sport events that do not belong to professional sports. The preference of the Customers to leave after a scandal means that they are bothered by doping scandals, rather than enjoying them.[15] Finally, Customers' preferences to stay if there was no scandal reflect the general interest in sports based on the view that Customers are unable to distinguish between undetected doping and clean sport even ex post. That is, their payoff of staying a supporter does not depend on whether d-n-s, c-t-s, or c-n-s is reached because they cannot distinguish between them.[16] And similarly, their payoff of withdrawing their support would not depend on whether outcome d-n-l, c-t-l, or c-n-l is reached.[17] Given A1 a Customer will stay a supporter if and only if there was no scandal –

the behavior under scrutiny. The following proposition shows that then outcome d-n-s – i.e. Athletes dope, Organizers do not test, and Customers stay supporters – is an equilibrium outcome.

Proposition 1 (doping equilibrium)**.** *Under Assumptions A1* $s^* := (Dope, Notest, LS)$ *is a SPNE.*

The proofs of this and all other propositions are collected in Appendix B. The intuition for Proposition 1 becomes apparent when considering the strategic interaction between Athletes and Organizers, given the Customers' behavior. Using the example payoffs from Figure 1, the following Matrix (1) is induced by Customers who stay if and only if there is no scandal. This can be contrasted with Matrix (2) that is obtained in the benchmark case that Customers unconditionally stay.

		Org	
		Test	Notest
Ath	Dope	1,4	**7,5**
	Clean	8,6	5,7

(1)

		Org	
		Test	Notest
Ath	Dope	2,8	7,5
	Clean	8,6	5,7

(2)

In the benchmark case, best response dynamics always follow a cycle, as it can be seen from Matrix (2). This is the classic observation in the inspection game that there is no pure strategy Nash equilibrium. In mixed strategies there would be an equilibrium where the probability of doping for our example payoffs is one over four. The strategic interaction in our model only differs from the benchmark case concerning the payoff in the upper left matrix entry, which is due to customers who leave after a scandal. As it can be seen from

Matrix (1), this breaks the cycle of deviations (in the best response dynamics) and yields the equilibrium in pure strategies established by Proposition 1. In words, Customers who leave after a scandal establish a threat to the Organizers such that they prefer not to detect doped athletes, even if they had done so in case that the Customers were uncritical (i.e. in the benchmark case where the Customers always stayed). Thus, the explanation for our qualitatively new result is that the introduction of (critical) Customers undermines the Organizers' incentives to uncover (the full extent of) doping because Organizers anticipate that they would suffer losses in the case of scandals. As a consequence, Athletes are not seriously tested and therefore decide to dope.[18]

Next, we discuss the robustness (and the practical implications) of the finding.

3.2 Robustness of the Doping Equilibrium

Proposition 1 only serves as a clear empirical prediction if there are no other equilibria and if its statement is robust to specification details. We first address uniqueness of the doping equilibrium and then study its robustness with respect to a continuous (instead of binary) action space, an imperfect test technology, and a different type of Customer.

Uniqueness Concerning uniqueness, we show that assumptions that are standardly made in inspection games are sufficient to exclude other equilibria.[19] These assumptions are collected in A2.[20]

Assumption 2 (inspection)**.** *In the inspection game the following assumptions are made on the preferences of Athletes and Organizers:*

Ath: *c-t-s* $\succ^{Ath}$ *d-t-s and c-t-l* $\succ^{Ath}$ *d-t-l, i.e. Athletes prefer not to dope if there are tests; and d-n-s* $\succ^{Ath}$ *c-n-s and d-n-l* $\succ^{Ath}$ *c-n-l, i.e. Athletes prefer to dope if there are no tests.*

Org: *d-t-s* $\succ^{Org}$ *d-n-s and d-t-l* $\succ^{Org}$ *d-n-l, i.e. Organizers prefer to test the Athletes if they*

are doped; and c-n-s $\succ^{Org}$ *c-t-s and c-n-l* $\succ^{Org}$ *c-t-l, i.e. Organizers prefer not to test if Athletes are clean.*

The Assumptions A2 are partially redundant with Assumptions A1, but further specify that Athletes prefer not to dope if tested and that Organizers prefer to test if and only if Athletes are doped. This reflects that Organizers are willing to detect doping, while testing is costly. The example payoffs provided in Figure 1 satisfy both A2 and A1.

Proposition 2 shows that the mild Assumptions A1 and the standard Assumptions A2 are powerful enough to rule out any equilibrium besides the previously found doping equilibrium.

Proposition 2 (uniqueness)**.** *Suppose Assumptions A1 and A2 hold.*
Then $s^* = (Dope, Notest, LS)$ *is the unique SPNE.*

Next, we address robustness of this result against three natural variations of the model.

Continuous Actions In reality customers might decide on the extent to which they still support, which is a richer action space than just the binary choice of *Stay* or *Leave*.

In order to relax the assumptions of binary actions for each player, we consider behavioral strategies. Under Assumptions A1 and A2, however, this does not affect the result. In equilibrium, Athletes dope with probability one, Organizers test with probability zero, and Customers certainly leave after a scandal and stay in the absence of a scandal.

If Customers *preferred* to partially reduce their support after a scandal, the question is whether the reduction is negligible such that we are in the benchmark case or whether the reduction is significant such as in our model where Organizers try to avoid scandals (cf. Assumptions A1: d-n-s $\succ^{Org}$ d-t-l). In the former case we would have an equilibrium in which players randomize, in the latter case the doping result holds.

Imperfect Test Technology Unrealistically, we have assumed that the test technology is free of errors. Extending our game to allow for false-positive and false-negative tests which occur with some probability ε, leads to a more realistic model, but not to a different result.

As it can be shown using the example payoffs, the unique SPNE is that Athletes dope, Organizers do not test, and Customers stay in the absence of a scandal as long as $\varepsilon < \frac{1}{2}$.[21]

Sophisticated Customers A crucial assumption throughout our analysis is that customers are unable to distinguish between undetected doping and clean sport even ex post such that they prefer outcome d-n-s over d-n-l. Our motivation is not the literal (game-theoretic) interpretation that Customers infer that there must be a high level of doping but do not care as long as there is no scandal (even if this might be true for some media companies or sponsors who we also consider in the role of Customers). Rather, we consider less sophisticated Customers who do not draw these inferences and therefore stay supporters in the absence of positive doping tests, which is arguably much more realistic than Customers who leave in that case. For example, most football fans do not seem to be trying to infer the underlying level of doping and to turn away their interest from competitions where it can be suspected that there are insufficient doping controls. However, it is a game-theoretically natural and economically interesting exercise to consider the effects of sophisticated Customers who make the inferences by analyzing the situation of strategic interaction and react to their belief about doping.[22] Let us briefly elaborate on this alternative (hypothetical) model, which is obtained when reducing the payoff of Customers for outcome d-n-s sufficiently to let d-n-l be preferred. As we show in appendix C.1, there are no pure strategy SPNE in that model. Customers still leave after a scandal, but all other equilibrium choices are mixed actions. The equilibrium belief of customers is that if there is no scandal, then the probability of doping is exactly fifty percent such that Customers are indifferent between staying and leaving. The probability of doping in equilibrium is $p^* \approx 59\%$. This is smaller than in our model with naïve agents, in which the pure strategy equilibrium predicts that all athletes (who are calculating dopers) dope. However, compared with the benchmark case, where Customers stay unconditionally (which we also refer to as the inspection game), sophisticated Customers lead to an increase in the probability of doping from 25% to 59%.

Thus, the qualitative result, that the introduction of Customers to the inspection game increases the level of doping, holds for both naïve and sophisticated Customers. The computed fractions of dopers, of course, depend on the absolute payoffs of the example and suggest that they have some cardinal interpretation.

In sum, it is a robust finding that the presence of customers who might withdraw their support accentuates the extent of doping. Let us now briefly discuss the interpretation and implications of this result.

3.3 Discussion of the Doping Equilibrium

The real world prediction of our simple model is that the number of dopers is large, while the probability of a doped athlete to be caught and punished is close to zero. The real extent of doping within professional sports is hard to assess and thus remains highly controversial. Theoretically, there are strong incentives to use performance-enhancing drugs. In particular, if our second prediction holds – that the probability of being detected and punished is small.[23] The explanation that our model provides for doping is that organizers do not want to uncover the full extent of doping because they anticipate that they would suffer losses in the case of scandals.

Our argument that Organizers lack the incentives for serious doping tests is in line with Eber (2002) who argues that Organizers have a low effort bias, which becomes stronger the more the authorities weight the economic stakes of professional sport.[24] Within his model, athletes form rational expectations about the effort of authorities to prevent doping, which leads to a credibility problem of the Organizers (Eber, 2002).[25]

The prediction that Organizers do not seriously test is also empirically difficult to assess. However, there are several pieces of evidence that support this view. For example, consider the anti-doping instrument called world anti-doping code (WADC). This is an international regulatory system that specifies test procedures, and lists of forbidden substances, and ac-

credits doping labs. (The WADC is an instrument of the world anti-doping agency WADA and we assume for the moment that the WADA is free of incentives issues in the fight of doping.) Implementing the WADC in some discipline would contribute to establishing a strict anti-doping regime. As it turns out, however, the problem of the WADC is the lack of compliance on the part of the international sports associations (Emrich and Pierdzioch, 2013). For example, the following prominent sports associations are reported to refuse the WADC: the International Football Association (FIFA), the International Tennis Federation (ITF), and the International Cycling Association (UCI) (Emrich and Pierdzioch, 2013).[26] Another indication that there need not be serious doping tests although many efforts in the fight against doping are claimed is the charter formulated by a movement called "change cycling now." The movement consists of sports journalists, former cycling officials, as well as of former cyclists, including a Tour de France winner. The charter strongly requests that the organization responsible for doping tests becomes independent and thus indirectly accuses the current institution as not being so. The charter expresses this as a principle to create doping-free cycling in the future: "The responsibility for deciding who is tested, when they are tested, and what drugs they are tested for, must reside in an independent entity that is beyond the control of the UCI."[27] Thus, even in cycling, where there is a long list of detected dopers, it seems that the probability of being detected when doped is not that high. We argue that in any discipline there are incentives to put insufficient effort into the detection of dopers.

Let us now return to our model and discuss efficiency.

3.4 Pareto Efficiency

Proposition 2 shows that the unique equilibrium outcome is d-n-s, which means that doping is prevalent. Whether this is a socially desirable outcome is not fully uncontroversial.[28] Let us discuss the assumptions that decide upon efficiency. In our model, the following assumption assures that d-n-s is indeed inefficient in the strong sense of being Pareto dominated.

Assumption 3. *For the preferences of the three players we assume the following:*

Ath: *c-t-s* $\succ^{Ath}$ *d-n-s* $\succ^{Ath}$ *d-t-s, i.e. Athletes prefer being tested and clean over being not tested when doped over being tested and doped.*

Org: *c-t-s* $\succ^{Org}$ *d-n-s, i.e. Organizers prefer the testing of clean Athletes over not testing doped Athletes.*

Cus: *c-t-s* $\succeq^{Cus}$ *d-n-s, i.e. Customers weakly prefer tested clean Athletes over not tested doped Athletes.*

Note that Assumptions A1, A2, and A3 are mutually consistent, e.g. the example payoffs of Figure 1 satisfy all three assumptions. The Assumptions A3 are plausible, but arguably much more controversial than A1 and A2. Athletes might dislike doping tests even if they are clean, because they have to be constantly available. However, we assume that Athletes are better off by being tested and clean than being doped, e.g. because doping would seriously affect their health. Organizers might have high costs of conducting doping tests and they might benefit from the performance of doped Athletes such that we had d-n-s $\succ^{Org}$ c-t-s. However, we take the view of benevolent Organizers who prefer to detect doped Athletes (as long as Customers stay) such that the relation is just the opposite. Finally, for Customers we keep the view that they cannot distinguish between the outcomes that do not include a scandal. Thus, d-n-s $\sim^{Cus}$ c-t-s $\sim^{Cus}$ c-n-s.

Clearly, under Assumptions A3, outcome d-n-s is Pareto dominated by outcome c-t-s. Thus, the unique equilibrium outcome in our model is not Pareto efficient. Outcome c-t-s, however, is not Pareto dominated by any other outcome as established by Proposition 3.

Proposition 3 (Pareto efficiency)**.** *Suppose Assumptions A1 and A3 hold. Then outcome d-n-s is not Pareto efficient, while outcome c-t-s is.*

In this subsection, we have shown that we are indeed in a social dilemma situation. The unique equilibrium outcome, which involves doping, is Pareto dominated by a doping-free

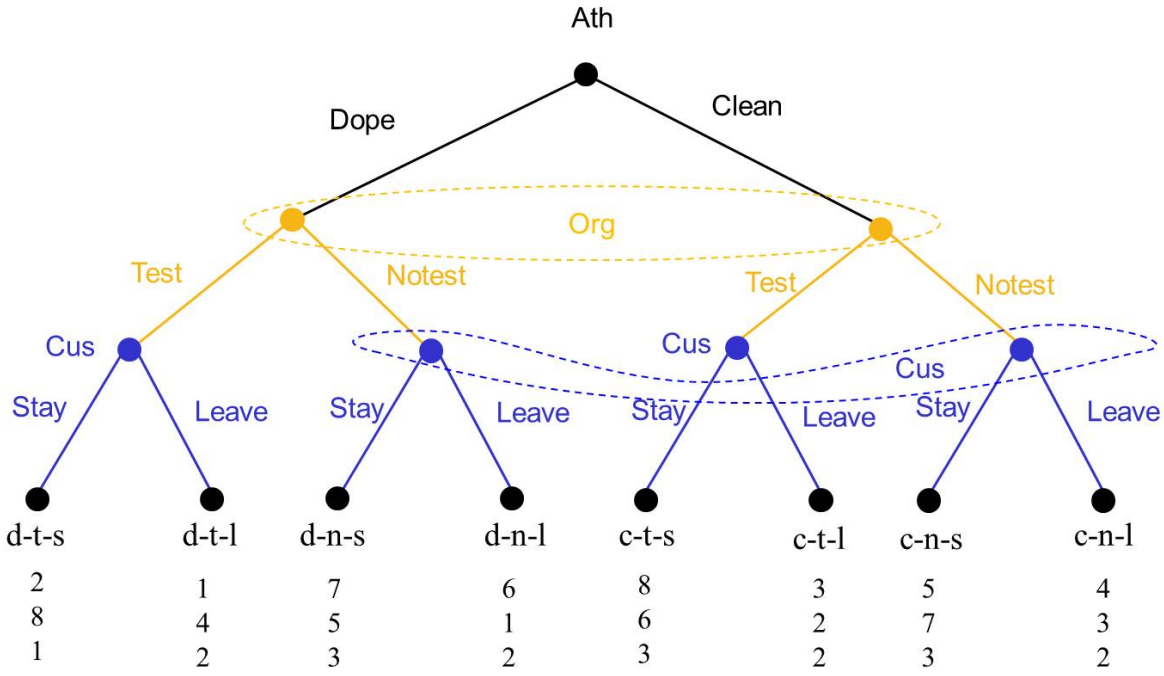

Figure 2: Structure of the game with well-informed Customers and an example for payoffs.

outcome. The next question is how the institutions can be changed such that the Pareto efficient outcome c-t-s becomes an equilibrium outcome. If the controversial assumption A3 is not accepted, then the doping equilibrium need not be Pareto dominated. Still, however, it is of high interest to find conditions for a doping-free equilibrium.

4 Inducing a Doping-free Equilibrium

We first establish the results, then we discuss current policy suggestions in the light of the model.

4.1 Change of Customers' Information Structure

In order to induce an outcome without doping, we change the information structure in the game. In particular, we let the Customers be also informed about doping tests that turned out to be negative. Consider the extensive game tree illustrated in Figure 2. As before,

Organizers decide on testing the Athletes without observing whether there was doping or not. The Customers then decide upon staying a supporter or leaving. The information they have for this decision now consists of three information sets: one is after a scandal $(Dope, Test)$, one after a negative test $(Clean, Test)$, and one after no test, which consists of the two histories $(Dope, Notest)$ and $(Clean, Notest)$. This yields eight strategies for the Customers, which we denote by $\{SSS, SSL, SLS, SLL, LSS, LSL, LLS, LLL\}$, such that the first letter stands for the action after a scandal, the second letter for the action after a negative test, and the third letter for the action if there were no tests. (The example payoffs in Figure 2 are as in Figure 1.)

In the game with less transparency (studied in the former section), under Assumptions A1 and A2 the unique equilibrium outcome involved doping. The following proposition shows that with more transparency there is a doping-free equilibrium, as well.

Proposition 4 (doping-free equilibrium)**.** *Under Assumptions A1 and A2 there are two SPNE in the game with finer information structure:* $\hat{s} := (Clean, Test, LSL)$ *and* $s^{**} := (Dope, Notest, LSS)$.

Proposition 4 shows that a change in the information structure in our model is sufficient to obtain a doping-free equilibrium. *Thus, the social dilemma can be overcome by establishing transparency.* The intuition for this result can be gained from the interaction of Athletes and Organizers, given Customers who play LSL. This is represented in Matrix (3) using the example payoffs. Organizers do test, given that they lose Customers in the absence of tests.

		Org	
		Test	Notest
Ath	Dope	1,4	6,1
	Clean	**8,6**	4,3

(3)

Considering behavioral strategies there is a continuum of equilibria in which Athletes are clean, Organizers test, and Customers stay after no tests with probability $r^* \leq \frac{3}{4}$ for

the example payoffs. Thus, there are doping-free equilibria although the probability that Customers leave in the absence of doping tests might be low.

However, the doping-free equilibria come with (at least) two caveats. First, they involve suboptimal behavior outside the equilibrium path. Indeed, after no test, the equilibrium strategy of the customers implies to leave (with positive probability), although this is not in line with Assumptions A1.[29] Second, there is still another equilibrium which involves doping.

The two issues would be solved at once, if Customers had different preferences. Suppose, hypothetically, that Customers were more skeptical about doping practices and therefore insisted on the proof of clean sports in order to stay supporters. With such Customers, the doping-free equilibrium $\hat{s}$ was unique, as we show in Appendix C.2. Moreover, there would be no more issue of suboptimal behavior outside the equilibrium path because the Customers' threat to leave after no tests would then be credible.

It thus not only takes a better information level for the Customers but also a change in preferences: they would have to insist on doping tests in order to unambigiously induce incentives for a doping-free sport.

4.2 Implications for Anti-Doping Policies

In the literature on doping incentives various approaches are suggested to solve the doping issue. Many of them concern the change of incentives on part of the athletes. On the one hand, it is suggested to change the punishments or to increase the fines for being doped (e.g. Haugen, 2004). In the light of our model, however, this approach is not effective since in equilibrium athletes are not tested and thus do not get punished. On the other hand, the suggestion is to decrease the benefits of doping, e.g. by reducing the prize spread between different ranks or by reducing the number of competitions (Eber and Thépot, 1999). But also decreasing the benefits of doping only affects the behavior of athletes if it succeeds in making doping less attractive than not doping, (i.e. the payoff of doping must be reduced to

such an extent that the ordinal preference that we assume in the model switches direction). This seems to be at least questionable.

Thus, for Athletes, which are calculating dopers, any anti-doping instrument has to make sure that the probability that doping is punished is sufficiently high. In this paper, we have identified the lack of the Organizers' incentives to really implement such a regime. A rather radical solution to these misguided incentives is to replace the actors that are responsible for doping tests. Indeed, it is currently debated in several countries (among them Germany) whether to establish a legislation that makes the state and its body responsible for the prosecution of dopers.[30] In some states, e.g. Belgium, this is already implemented. In principle, the proposed shift of responsibility is a solution to the lack of control since the police and the courts do not have the conflict of interest that NADAs and sports associations have. However, this approach is only fruitful if it is practically possible to fully circumvent the Organizers, i.e. if the collaboration of sports associations and NADAs is not crucial for the prosecution of doped athletes.

In Subsection 4, we have elaborated on a different approach to fight doping. We show how Customers can contribute to doping-free sports if they are sufficiently well-informed. In particular, we require information about doping tests which admits Customers to condition their support for the sports event on the presence of doping tests (as illustrated in Figure 2). Whether or not Customers really insist on doping tests, then determines the extent of doping in equilibrium (Proposition 4 and C.2). Thus, a direct implication of our model is that *transparency* about the doping tests and their outcomes should be established.

This requirement is not satisfied in professional sports today. Most of the data that is publicly available only contains cases of detected doping but not information about the extent of testing. For example, the Internet Anti-Doping Database created by Norwegian sports journalist Trond Husø contains more than 5000 cases, but mostly of detected dopers. In the absence of doping scandals, this does not allow Customers to discriminate between clean sports and undetected doping (such as illustrated in Figure 1).

One type of actors who is in principle capable of establishing transparency are sports associations who we study as Organizers in our model. However, as argued above, such organizations lack incentives to do so. Dilger and Tolsdorf (2004) and Striegel et al. (2010) assume that their lack of compliance is one reason why data on doping is so limited. In order to achieve more transparency, the WADA could open the access to their database called ADAMS. ADAMS was introduced to simplify the organization and realization of doping tests.[31] Currently, only certain actors of the immediate sports environment are allowed to use ADAMS. Opening the access to ADAMS seems to be a cheap way to establish transparency, while such a policy might involve several new issues, including the violation of privacy rights. Moreover, it can be difficult or costly to understand and interpret the data for Customers. A much simpler suggestion is that the WADA makes public to which extent sports associations and NADAs comply to anti-doping standards. This could be a simple rating which gives Customers a clear signal about which disciplines and events are credible in their fight against doping. Of course, this requires independence on part of the WADA, which is also doubted (cf. Eber, 2002; Preston and Szymanski, 2003), but, in principle, we conclude that there should be an independent rating or certifying agency that officially measures to which extent certain sports events have implemented an anti-doping regime. Whether or not doping prevails in the future is then dependent on the Customers' preferences.

5 Concluding Remarks

In this paper we have extended the inspection game (cf., e.g., Avenhaus et al., 2002) by a third player: customers, who can withdraw their support. As it is shown in the application of doping in professional sports, the behavior of critical customers accentuates the fraudulent behavior.[32] Customers who are ready to leave after a doping scandal, undermine the organizers' incentives to test athletes on performance-enhancing drugs and to convict them on doping. As a consequence, athletes have stronger incentives to dope although this

need not be in the best interest of any of the three types of players. Our analysis substantially strengthens the argument already outlined by Eber (2002) who comes to the following conclusion: The institution responsible for doping controls "may have some temptations to slacken its antidoping effort when confronted with doping affairs to preserve the economic value of the shows (e.g., the Olympic Games organized by the IOC [International Olympic Committee]). Knowing that, athletes may rationally not believe in strong antidoping policies and may then continue to choose high levels of doping." Our analysis of incentives suggests that the few spectacular cases of convicted dopers are not delinquent exceptions, but rather unlucky cheaters or scapegoats, because the probability of being detected when doped is low (cf. Preston and Szymanski, 2003). To elaborate on potential solutions for the doping dilemma, we show that a change in the information structure in our model serves to obtain a doping-free equilibrium (Proposition 4). The crucial change is to establish transparency in the sense that customers know whether there were negative tests or there were no serious tests (cf. Figure 2 versus Figure 1). This allows customers and other stakeholders to condition their support on the presence of serious anti-doping tests. Practically, the required transparency could be established by a certificate or rating that shows which sports events have established a strict anti-doping regime.

However, our model is not restricted to doping and professional sports. In many different industries, e.g. textile or food, customers do not know very well the production process of the goods that they consume. In particular, it is hidden whether the producing companies complied to all standards and ethical norms – except if there is a scandal in the news. Scandals make public, e.g. the use of child labor in the production of clothes, as well as the violation of hygienic standards in the food industry. After the detection of such fraudulent activities in some organization, there is a loss of reputation and critical customers may react with a boycott. There are not few contexts, where the agent that is able to detect the potential fraudulent activities is also affected by such a scandal. Consider a company in the role of the Organizer, who has business relations with another firm (Athlete) that does potentially

not comply to certain ethical standards. Detecting norm violations would also undermine the reputation of the company itself. Customers who react with a boycott substantially increase the loss of the company and thereby undermine its incentives to uncover (potential) scandals.[33] When there is no other agent who is capable of detecting the fraud without the help of the company, the number of fraudulent activities might even increase. As our model shows, this outcome can be altered if customers are informed about control activities of all companies by some independent institution. Thus, transparency is necessary in order to overcome this type of social dilemma.

Notes

[1]Inspection games are discussed by Dresher (1962), Maschler (1967), Tsebelis (1989), and Avenhaus et al. (2002), among others.

[2]Results of an online-survey reveal that spectators require that athletes serve as role models for a clean and doping-free sport (Emrich et al., 2014).

[3]As a survey on the Olympic Games shows, spectators, fans etc. want to see records and high performances but only under compliance of the rules (Messing and Müller, 1996).

[4]The United Nations Educational, Scientific and Cultural Organization (UNESCO) has established a sizable fund dedicated to "the Elimination of Doping in Sport" (c.f. http://www.unesco.org/new/en/social-and-human-sciences/themes/anti-doping/fund-for-the-elimination-of-doping-in-sport/projects/, last access: July 1, 2014). The European Commission and its member states are currently developing an anti-doping law based on the view that doping is "seriously undermining the principles of open and fair competition" (c.f. http://ec.europa.eu/sport/policy/societal_role/doping_en.htm, last access: July, 2014).

[5]E.g. Striegel et al. (2010) found an eight times higher number of drug abuse than it is officially confirmed.

[6]Interaction among heterogeneous athletes is analyzed by Berentsen (2002), Berentsen and Lengwiler (2004), and Kräkel (2007).

[7]The fact that in the inspection game there is only one athlete does not mean that the ideas from the strategic interaction between athletes are neglected. In particular, it is assumed that under no controls athletes prefer to dope, which is based on considerations of competition among athletes.

[8]The definition of doping is itself an issue that is worth a discourse (cf. Eber, 2006). The binary decision to dope or not to dope is a simplification of a set of decisions which might also be considered as gradual. The simplification can be justified by at least two reasons. First, it is often unambiguous whether an athlete uses illicit substances or not. Second, there is a subjective interpretation of whether the athlete considers that he/she cheats or not.

[9]The WADA is an international institution founded in 1999 in Lausanne. Its main task is the world-wide coordination of anti-doping activities such as detection, deterrence and prevention. Moreover, the WADA coordinates doping tests with national anti-doping agencies (NADAs).

[10]For a richer description of the institutional setting see Emrich and Pierdzioch (2013).

[11]Eber (2002) suspects that even the WADA is not independent: "The problem is that WADA [...] is a product of the IOC [International Olympic Committee] and is probably far from being independent of it."

[12]The fact that sometimes sport events publicly announce the number of tests they have carried through does not contradict this assumption. Still, Customers do not know whether the Athletes have been seriously and systematically tested.

[13]The specification of explicit payoffs or utility levels forces us to make many assumptions that are not at all necessary for the derivations of the model implications. The set of assumptions we will really use leaves room for many preference orderings and only one of them is represented by the example payoffs in Figure 1. The advantage of such a parsimonious approach is that eventually derived results are robust against changes of specification details.

[14]This interaction between several Athletes is often modeled as a prisoner's dilemma. There the dominant strategy is to dope, as we assume this behavior here for the case of no tests and one representative Athlete. In reality, there are also Athletes who are unconditional non-dopers (Pitsch et al., 2010). Their (trivial) behavior is not studied within our model.

[15]In reality there might be Customers who enjoy (doping) scandals. We will consider such customers and, equivalently, uncritical customers, who always stay supporters, as a benchmark later on. However, we study a more critical kind of Customers here.

[16]Basically, this assumption also means that Customers do not respond to what they infer about the behavior of other players. Alternatively, we could assume that Customers also withdraw their support in absence of positive doping tests, if they infer the use of doping by analyzing the situation of strategic interaction. This alternative assumption and its implications are discussed in Subsection 3.2.

[17]A similar interpretation holds if we consider sponsors and media companies in the role of the Customers. Moreover, there is a second interpretation of this assumption for these actors. It might be that they are able to distinguish ex post between different outcomes, but do not strongly care about doping as long as it is not officially detected.

[18]This result is not due to other explanatory factors since under our assumptions testing can be almost costless, the benefits of doping need not be high, and the disutility of being detected can be huge. Importantly, our argument is not that doped Athletes produce higher performances which creates utility for the Customers or Organizers, although this idea would

not alter the result.

[19]In an inspection game an inspectee has to decide whether to comply or deviate from a norm, while an inspector can choose between inspecting or not inspecting the action. To embed this standard game into our notation we would consider the Athlete as the inspectee, the Organizer as the inspector and for the Customers which are standardly excluded, we would assume constant behavior. That is, our model differs from the standard inspection game only in that Customers sometimes withdraw support, while standardly Customers always stay supporter or, alternatively, they never support.

[20]Usually, the inspection game is represented by numerical payoffs. This implies additional assumptions to the ones collected here. However, those additional assumptions are neither consensual in the literature, nor are they necessary for our results (as long as we obtain pure strategy equilibria).

[21]The proof of this claim can be requested by the authors. The issue of imperfect test technology in doping tests is investigated by Kirstein (2012). He studies a game, in which the enforcing agency receives an informative but imperfect signal about whether an athlete is doped or not.

[22]We thank an anonymous referee for this suggestion.

[23]In the absence of serious controls, athletes are in the classic (prisoner's) dilemma because they either can get a competitive advantage by doping or they have to assume that their rivals are doped (cf., e.g., Breivik, 1992).

[24]Of course, there are also other reasons, why detected doping leads to losses. For example, a national sports association might have an interest that athletes from its country are successful in international competition.

[25]Concerning Customers' perceptions, one way to increase the public credibility of anti-

doping activities might be to detect doping cases but very few of them. Indeed, we have not included the idea that the conviction of a few athletes enhances the credibility of clean sport. We have focused on the main effect, which is that the conviction of many athletes undermines the credibility of a sports event or even of a whole discipline. Importantly, we are not arguing that Organizers are unwilling to fight against doping, but simply that they have strong incentives not to fully uncover doping activities.

[26]The WADA does not have effective instruments to punish organizations that do not comply.

[27]The full charter can be found at
http://www.changecyclingnow.org/wp-content/uploads/2012/12/Charter-of-the-Willing.pdf
(last access: July 30, 2014).

[28]Savulescu et al. (2004) discuss several arguments concerning the usefulness of anti-doping rules and conclude that performance-enhancing drugs should be legalized. Concerning fairness, they find that legalization is in line with the "spirit of sport" because it is still the aim to find the best athlete among all competitors.

[29]Subgame perfection simply does not rule out this incredible threat. The notion of perfect Bayesian equilibrium would do so and only render s^{**} as an equilibrium.

[30]The discussion caught new fire with the recent case of Lance Armstrong.

[31]ADAMS has four main tasks: First, athletes are required to enter their actual wherabouts and other users will be informed about actual infringements against reporting standards (Athlete's Wherabouts). Second, it is also possible to manage medical exceptional permissions (Therapeutic Use Exemptions Management). Third, ADAMS informs about doping tests, infringements, and sentences (Information Clearing House). Finally, ADAMS is supposed to ease the scheduling of doping tests and the preparation of doping profiles (Doping Control Platform).

[32]Other counter-intuitive results of the inspection game are already known (Holler, 1993; Andreozzi, 2004; Friehe, 2008). They concern the indifference of the mixed strategy Nash equilibrium, which implies that a change of payoffs for one player does not affect the equilibrium behavior of this player, but only its opponent's. Maximin strategies are used to address this issue (cf. Aumann and Maschler, 1972; Holler, 1990).

[33]There is empirical evidence on a similar issue in the context of juridical judgments: An increase in the defined punishment, e.g. from prison sentence to capital punishment, can lead to a reduction of the number of convictions.

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A Appendix: Some Evidence on the Importance of Customers

Customers of a sports event do not only expect high performances from the athletes but also their compliance to the rules. During the Olympic Games in Barcelona 1992, for example, 91% of 475 interviewed spectators answered that they want to see high performances at the Olympic Games, but a majority of them (58%) considers doping as a *threat* to the Games (Messing and Müller, 1996). For the Olympic Games of Sydney 2000 and Athens 2004 the number of people who agrees that doping is a threat has even increased to 69% and 82% (Messing et al., 2008) and doping is considered as the most severe threat for Olympic Games, ranking above terrorism and corruption (Messing et al., 2004). This view is not restricted to spectators, but it is also predominantly shared by athletes, students of sports science, and media representatives (Tröger, 2006). But what is the actual "threat" that starts out from doping in sports? Probably such a scenario can be best studied in an event for which it is known that doping is widespread – such as the world's most famous cycling tour, the Tour de France.

The recent exposure of the doping affair concerning the seven-times Tour de France winner (Lance Armstrong) is just one very spectacular case in a long list of disclosures. In 1998 a whole cycling team (Festina) was excluded from the Tour de France after a large amount of performance-enhancing drugs was found in a team car. In the 2006 Tour de France, an affair centered on a physician (Eufemiano Fuentes) led to the expulsion of several participants and some days after the Tour de France 2006, it was detected that the winner (Floyd Landis) was positively tested on performance-enhancing drugs. The fact that, in this case, as well as in many other prominent cases, doping delicti became public after the Tour de France, implies that the customers' reaction to the scandal cannot be simply measured by a change of the audience ratings during one Tour (Van Reeth, 2013). One year after the Fuentes affair, the German public-sector TV channel quit the live-broadcast of that actual Tour de France when

a German cyclist (Patrik Sinkewitz) was convicted on doping. Although this TV channel reported from the Tour de France again in the years 2008 until 2011, they finally quit in 2012. The reason for that was a sharp decline in the audience ratings from one year to the next. (While the market share amounted to 13 percent in year 2008, there was a decline to approximately 9 percent in 2009.) Not only TV channels, also sponsors reacted with exit. For example, the cycling team-sponsor Phonak quit, after their team leader (Floyd Landis) was convicted of doping, and a German cycling team-sponsor (Gerolsteiner) quit after two German cyclists (Stefan Schumacher, Bernhard Kohl) were found guilty. A majority of fans supports such reactions of sponsors and TV broadcasters (Solberg et al., 2010). In sum, the recent history of cycling demonstrates that the reaction to the disclosures of systematic doping practices is the *withdrawal of support* from several stakeholders. This is true for media companies, sponsors, and – last but not least – customers (spectators). It is a notable fact that there are customers who still support the Tour de France despite (or maybe even because of) the doping scandals. However, it seems undeniable that the organizers of the event have suffered substantial losses due to the withdrawal of support of many customers, sponsors, and media companies.

Similar scenarios of withdrawal of support have not happened in most of the other disciplines. As the Olympic Games in London show, the interest in sports and, particularly, in track and field athletics is huge. This does not mean that track and field athletics is free of doping. For example, the US sprinter Justin Gatlin who sprinted to his personal best in London has a background on doping delicti. Further, the two nearest rivals (Tyson Gay and Asafa Powell) of the star in track and field athletics, Usain Bolt, were convicted on doping in 2013. These cases are not that exceptional: among 64 world class sprinters on the 100 meters track Dilger and Tolsdorf (2004) found that 16, i.e. 25%, have been convicted on doping somewhen in the period from 1997 until 2002. Also, the U.S. sports leagues for American Football and Baseball (NFL, MLB) have to deal with some doping scandals. For example, baseball star Alex Rodriguez was suspended for 211 matches until the end of season 2014

because of the suspicion that he consumed banned drugs.

It seems that, despite such cases, the public perception in many disciplines is that most of the athletes do not use performance-enhancing substances. For example, in the year 1988 the most prominent 100 meters track star Ben Johnson was convicted on doping, while during the next Olympic Games (in Barcelona 1992) only every fourth or fifth spectator (22%) agreed that doping and manipulation are determining factors of the Olympic performances (Messing and Müller, 1996). In professional Tennis or Soccer doping is rarely a topic at all.

Concerning the Tour de France, in contrast, most of the TV spectators (89%) in a survey assumed that doping is a common practice. (These figures are reported by a German newspaper and can be found at http://www.zeit.de/online/2007/28/tour-de-france-medienkritik, last access: July 30, 2014.)

If the public perception of clean sport is critical for customers and other stakeholders to keep their support, then organizers have strong incentives to avoid a list of scandals comparable to the one of the Tour de France. Hence, the critical role of customers lies in their potential to withdraw support. This is exactly the aspect of customers that is incorporated in our model.

B Appendix: Proofs

B.1 Proof of Proposition 1

Proof of Proposition 1. The only proper subgame of our game starts at node "scandal" $(Dope, Test)$. L is a Nash equilibrium (NE) in this trivial subgame. The second subgame is the game itself. Suppose Customers play LS in this game.

For the decisions of the Athletes and the Organizers LS induces the following ma-

trix (B.1).

$$
\begin{array}{cc|cc}
 & & \multicolumn{2}{c}{Org} \\
 & & \text{Test} & \text{Notest} \\
\hline
Ath & \text{Dope} & \text{d-t-l} & \textbf{d-n-s} \\
\hline
 & \text{Clean} & \text{c-t-s} & \text{c-n-s} \\
\hline
\end{array}
\tag{B.1}
$$

Now, it can be immediately observed that by applying A1, Athletes dope and Organizers do not test are mutual best responses since d-n-s $\succ^{Ath}$ c-n-s and d-n-s $\succ^{Org}$ d-t-l. Moreover, LS is a best response to $(Dope, Notest)$ because by A1 it holds that d-n-s $\succ^{Cus}$ d-n-l. □

B.2 Proof of Proposition 2

Proof of Proposition 2. $s^* = (Dope, Notest, LS)$ is a SPNE by Proposition 1. We show uniqueness of s^* by excluding all other strategy profiles from being an equilibrium. In the subgame that starts with the scandal, Customers choose leave in equilibrium (by A1). Thus, there are no SPNE where Customers play SS or SL. Given Customers play LL, there is no mutual best response for Organizers and Athletes because this is an inspection game situation (A2). Thus, only the four strategy profiles with Customers choosing LS remain. A1 excludes $(Dope, Test, LS)$ by d-n-s $\succ^{Org}$ d-t-l and $(Clean, Notest, LS)$ by d-n-s $\succ^{Ath}$ c-n-s from being an equilibrium. Finally, $(Clean, Test, LS)$ is not an equilibrium because c-n-s $\succ^{Org}$ c-t-s (A2). □

B.3 Proof of Proposition 3

Proof of Proposition 3. The implication that d-n-s is Pareto dominated by c-t-s is immediate from A3.

To establish that c-t-s is Pareto efficient, let us show that for any other outcome d-t-s, d-n-s,..., c-t-l, c-n-l there is at least one player who strictly prefers outcome c-t-s. From A3 we get: c-t-s $\succ^{Ath}$ d-n-s $\succ^{Ath}$ d-t-s. A3 and A1 imply that c-t-s $\succ^{Ath}$ d-n-s $\succ^{Ath}$ c-n-s. From A1 we get: c-t-s $\succ^{Ath}$ d-t-l. From A3 and A1 we get: c-t-s $\succ^{Cus}$ d-n-s $\succ^{Cus}$ d-n-l. From A1

we get: c-t-s $\succ^{Cus}$ c-t-l. Finally, from A1 we get: c-t-s $\succ^{Org}$ c-n-l. □

B.4 Proof of Proposition 4

Proof of Proposition 4. The game has two proper subgames: one starts at node $(Dope, Test)$ and one starts at node $(Clean, Test)$, cf. Figure 2. In both subgames only Customers act and by assumption A1 they will choose *Leave* in the first one and *Stay* in the second one. Thus, in each SPNE the Customers' strategy is either LSL or LSS. The following matrices show the decisions of Organizers and Athletes given that Customers choose LSL (Matrix B.2) or LSS (Matrix B.3):

		Org	
		Test	Notest
Ath	Dope	d-t-l	d-n-l
	Clean	**c-t-s**	c-n-l

(B.2)

		Org	
		Test	Notest
Ath	Dope	d-t-l	**d-n-s**
	Clean	c-t-s	c-n-s

(B.3)

Matrix (B.2) leads to mutual best replies $(Clean, Test)$. LSL is also a best reply to $(Clean, Test)$ because c-t-s $\succ^{Cus}$ c-t-l by A1 such that $\hat{s}$ is a SPNE. There are no other equilibria with LSL because A2 yields deviations from outcomes d-n-l and c-n-l, while d-t-l is not a candidate because, again, c-t-s $\succ^{Ath}$ d-t-l by A1.

Matrix (B.3) leads to mutual best replies $(Dope, Notest)$ (as already shown in proof of Proposition 2). LSS is also a best reply to $(Dope, Notest)$ because d-n-s $\succ^{Cus}$ d-n-l by A1. There are no other equilibria with LSS because A2 yields deviations from outcomes c-t-s and c-n-s, while d-t-l is not a candidate because c-t-s $\succ^{Ath}$ d-t-l by A1. □

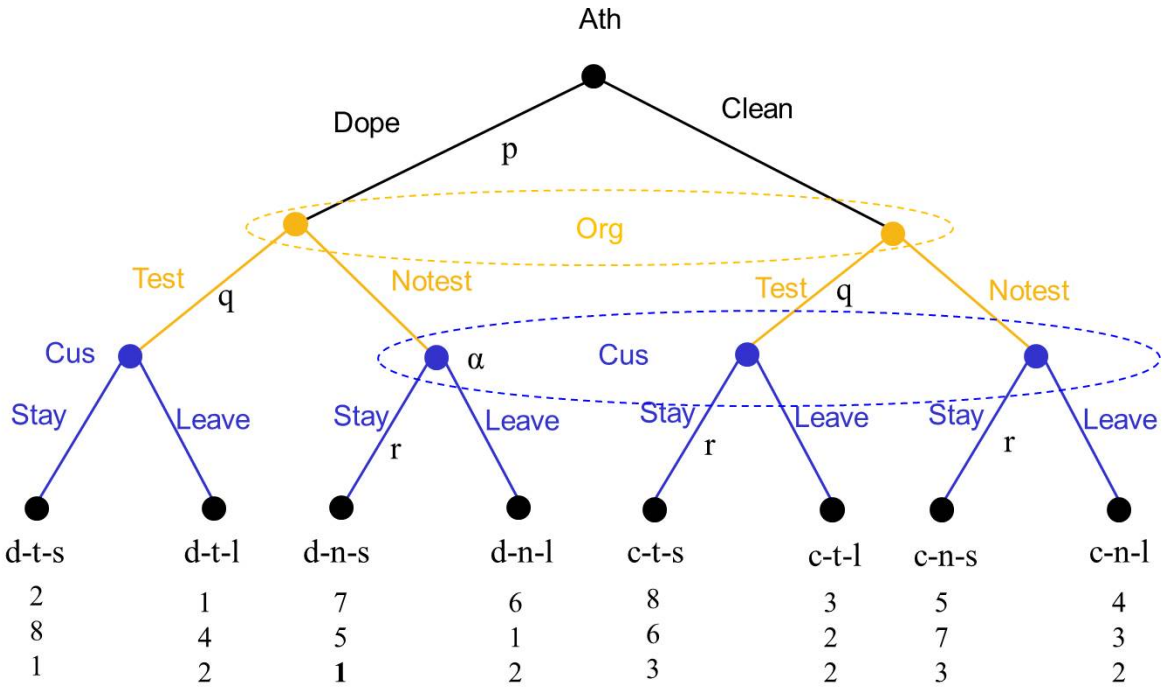

Figure 3: Structure of the game and an example for payoffs when Customers observe doping ex post.

C Appendix: Model Variations

C.1 Sophisticated Customers

Let us briefly elaborate on the alternative model discussed in Subsection 3.2, in which Customers are sophisticated and infer the level of doping from the situation of strategic interaction. Figure 3 shows this variation of our model. The difference to the payoffs of the initial example presented in Figure 1 is only the Customers' payoff at d-n-s, which turned from 3 to 1. Proposition C.1 shows that the Probability of doping in equilibrium is substantial, while the probability of being tested is much smaller.

Proposition C.1. *For the game depicted in Figure 3, in the unique SPNE Athletes dope with probability* $p^* = \frac{\sqrt{209}+23}{64} \approx 0.59$*, Organizers test with probability* $q^* = \frac{2\sqrt{209}-18}{23+\sqrt{209}} \approx 0.29$*, and Customers leave after a scandal with certainty and stay after no scandal with probability* $r^* = \frac{\sqrt{209}-3}{20} \approx 0.57$*. This is also a PBE with the equilibrium belief* $\alpha^* = \frac{1}{2}$ *that customers*

are not doped if there was no scandal.

Proof. To describe the behavioral strategies, let p be the probability that the Athletes dope, let q be the probability that the Organizers test, and let r be the probability that Customers stay after no scandal, as depicted in Figure 3. After a scandal Customers leave with probability one in any SPNE. Note first that $p = q = 1$ cannot be part of an equilibrium since Athletes prefer not to dope if tested. Thus, there is a positive probability for no scandal in equilibrium. From the expected utility of the pure strategies it is directly derived that Athletes weakly prefer to dope (i.e. $p = 1$) if and only if

$$q \leq \frac{2}{5r+4}, \tag{C.1}$$

Organizers weakly prefer to test (i.e. $q = 1$) if and only if

$$p \geq \frac{1}{4-4r}, \tag{C.2}$$

and Customers weakly prefer to stay (i.e. $r = 1$) after no scandal if and only if

$$p \leq \frac{1}{2-q}, \tag{C.3}$$

Suppose, $p = 1$. This implies $r = 0$ by (C.3), which together with (C.2) implies $q = 1$. Now, (C.1) yields $p = 0$, a contradiction. Alternatively, suppose $p = 0$. This implies $r = 1$ by (C.3), which implies $q = 0$. Now, (C.1) yields $p = 1$, a contradiction. We conclude that in equilibrium, $p \in (0, 1)$. Hence, Athletes must be indifferent, i.e. $q = \frac{2}{5r+4}$ by (C.1). Thus, Organizers are also indifferent, i.e. $p = \frac{1}{4-4r}$ by (C.2). Since $p \leq 1$, $r \leq \frac{3}{4}$. Thus, Customers must either choose $r = 0$ or be indifferent.

If $r = 0$, then $q = \frac{1}{2}$ by (C.1) and $p = \frac{1}{4}$ by (C.2). This leads to a contradiction since (C.3) implies $r = 1$.

Thus, in equilibrium Customers are indifferent as well, i.e. $p = \frac{1}{2-q}$ by (C.3). Solving the

system of equations in which (C.1), (C.2), and (C.3) hold with equality yields p^*, q^*, r^*, i.e. the first part of the proposition (we used the quadratic formula for the exact expressions). By plugging in p^* and q^* into $\alpha = \frac{p(1-q)}{p(1-q)+1-p}$, we get $\alpha^* = \frac{1}{2}$, which makes Customers indifferent between staying and leaving.

□

C.2 More Critical Customers

Let us briefly elaborate on the model variation mentioned in Subsection 4.1, in which Customers are more critical than in our model. Thus, suppose that d-n-l $\succ^{Cus}$ d-n-s and c-n-l $\succ^{Cus}$ c-n-s, i.e. Customers preferred to withdraw their support if there are no doping tests. This is in contradiction to Assumptions A1. Let us hence change A1 to A1' such that these two orderings have changed, while all other binary comparisons are left unchanged. (This change of preference reflects that Customers are here assumed to be more skeptical about doping practices and therefore insisted on the proof of clean sports in order to stay a supporter.) Under transparency, these alternative preferences rule out all doping equilibria as the following proposition shows.

Proposition C.2. *Under Assumptions A1' and A2* $\hat{s} = (Clean, Test, LSL)$ *is the unique SPNE in the game with well-informed Customers (cf. Figure 2).*

Proof. The beginning of the proof of this proposition is fully analogous to the first and second part of the proof of Proposition 4 because no assumption of A1' is used that does not coincide with the assumptions in A1. That is, we can restrict attention to two strategies of the Customers LSL and LSS, while for LSL, cf. Matrix (B.2), we find the mutual best response as $(Clean, Test)$ such that $(Clean, Test, LSL)$ is a SPNE. For the case of LSS, cf. Matrix (B.3), now the difference between A1' and A1 becomes relevant. Matrix (B.3), again, leads to best replies $(Dope, Notest)$. However, LSS is not a best reply to $(Dope, Notest)$ because d-n-l $\succ^{Cus}$ d-n-s by A1'. There are no other equilibria with LSS because A2 yields

deviations from outcomes c-t-s and c-n-s, while d-t-l is not a candidate because c-t-s $\succ^{Ath}$ d-t-l by A1'. □