Redemption for Olympic Weightlifting: Is a Doping-Free Future Possible?

Brian Liu[1]

[1] USA

Correspondence: Brian Liu, USA. E-mail: brianliu333@gmail.com

Abstract

The purpose of this article is to find if a doping-free equilibrium is possible in the sport of Olympic Weightlifting. A thorough literature review was conducted as well as a 3 player model (Athletes, Management, Customers) similar to the basic inspection game. It was found that with the new payoffs introduced after the McLaren report, where high level corruption was uncovered and exposed, a doping-free N.E. (Nash Equilibrium) can be achieved. The principal factor was that customers must demand test results from the management of all athletes, and be supportive when dopers are caught. A complete contrast to the current system where the organizations completely control the information flow and decide when and if a negative was found. If this change wasn't implemented, management would prefer to keep all the tests hidden to ensure that profits would continue to rise. However, this conclusion is the most pareto efficient result as athletes won't have to use drugs that would harm their body for years to come. And customers can enjoy the continuous advancement of technique and training in Olympic Weightlifting.

Keywords: cheating, doping, professional sports, olympic weightlifting, inspection game

1. Introduction

Ever since the early 1900s when performance-enhancing drugs were first found and proven to be effective, the regulation of these drugs has been a brutal battle between organizations and athletes. Whenever organizations find better ways of testing, athletes then find better ways of hiding their use. This battle has historically been a cat and mouse game that always occurs to some degree in any top-level Olympic sport. However, weightlifting has caught a higher number of cheaters than the norm, surpassed only by track and field (Note 1). There are two major reasons why the rate of cheating in weightlifting is so high. One, weightlifting is a strength sport, so these drugs usually have the biggest impact on the athletes. And second, until recently, there was a lack of stigma and a culture that accepted doping at the highest levels. Now, fans are demanding more and more that organizations put more effort into striving for a clean sport.

Fans are especially concerned now after the scandal that has just occurred. At the start of 2020, an independent investigation into the IWF (International Weightlifting Federation) began, causing waves of discussion and debate among the weightlifting community. The McLaren report (Independent Investigator Report To The Oversight and Integrity Commission Of International Weightlifting Federation, 2020) unearthed mountains of evidence that proved Tamas Ajan, President of IWF for almost half a century, guilty of multiple cases of corruption and bribery. How he did this is surely now a question on everyone's mind. Well, he used his complete control over the IWF's profits and money to control everything else in the entire organization. There were even reports that he put his own family members and trusted allies in key positions of the financial sector to maintain complete control of the IWF's secretariat. After decades of this behavior, the investigators found that more than 10.4 million dollars cannot be accounted for. What he then did with all this wealth was to buy votes for his re-election. He would make voters take a picture of their ballot, and if they voted correctly (for him), he would then forward them money directly. To be completely sure that this process didn't fail, he even changed the rules so that voters couldn't go back and change their votes, and they had to use a stamp so they couldn't use erasable ink. And through these votes and his many hidden bank accounts, he was able to get re-elected time and time again.

The worst part is that this isn't even close to all he did. While the board and president should usually have no oversight or authority at all over the drug testing system, Ajan used this system as a way to earn profits and stay in power. The Olympic and World Championship games have tremendous economic importance, especially for

more developing countries that currently aren't very influential. For these countries, an Olympic medal is such a big deal that they are more than willing to pay for them. Ajan took advantage of this fact, and he allowed athletes' positive drug tests to be swept under the carpet if the national organization was able to pay him a certain amount of money, usually in cash. In one incredulous story, the Albanian Weightlifting Team smuggled $100 000 over the border in order to compete in the Olympic Games. And that's not even all the evidence of his wrongdoings. Investigators found a leaked letter from the Azerbaijan Olympic Committee's president where he thanked Ajan for allowing his athletes to compete. They pushed deeper and found that 18 Azeri athletes were caught on illegal substances that same year but had their suspensions "delayed" and were able to compete as if they were natural. Investigators later found positive test results from 21 Turkish athletes, as well as 41 from other athletes, all kept under wraps. This is a huge breach of the basic moral obligation the organization has: to be open and trustworthy to the fans of weightlifting, and beyond that, to be unbiased and fair to the athletes. Instead, Olympic medals were quite literally being packaged and bought based on who was able to pay the $100 000. (Independent Investigator Report To The Oversight and Integrity Commission Of International Weightlifting Federation, 2020)

After all this information was released to the public, the backlash was brutal for Ajan and his followers. He has since resigned and so has the majority of the board, and a new temporary president has been put in. The new board is currently trying to fix all the problems Ajan has caused, sending the doping cases to WADA (World Anti-Doping Agency), and making major reforms that benefit natural athletes. This is where our research paper and game model comes in. I am trying to see if a doping-free equilibrium is possible in this three-player game (Athletes, Management, Customer), with these new payoffs and game assumptions. And with this information, I hope to deduce if a future is possible where all the athletes we see on stage are natural and tested. Then and only then, can true competition begin to occur.

The rest of this paper is organized as follows: The second section will be the literature review. The third section presents and explains the game model. The fourth section describes the payoffs for all three players, as well as the doping-free nash equilibrium. The fifth section discusses the equilibrium and resolves commonly asked questions. The sixth section concludes.

2. Literature Review

The research paper titled Crime and Punishment in the Classroom was written to support the data found in other works of literature on the best way to prevent cheating from happening. Their game is a 3 player static game with complete information. Two students who choose to cheat or not and a professor who must choose the effort level and exertion. The model mainly focused on the level of effort a student needed to put in to get a good grade, and how that effort could be undermined since cheating can result in the same grade as the person next to you. Another important factor was the amount of effort the professor put in and how lenient/strict he is as that impacted how likely the student is to cheat. They found that the most important thing was that the professor must be well motivated and trying to achieve a fair environment for all during the tests. These results were similar to my own research and model, the more effort the management/professor puts into looking for cheaters, the less incentive there would be for athletes/students to cheat. (Griebeler 2017)

The research paper "The Performance-Enhancing Drug Game Reconsidered" looked at how incorporating fair play norms into the model would change the results dramatically. In their game model, by adding these norms, it changed the model from a prisoner's dilemma to a stag hunt game. They were able to find a payoff-dominant no doping pure strategy equilibrium as well as a risk-dominant doping equilibrium. They found that the deciding factor was for the athletes to be able to coordinate with each other through a trusted and reliable source. They suggested that organizational agreements or an anti-doping charter are a possible option to prevent doping. This paper is very interesting in the way they assume athletes would be happy to not dope as long as other athletes do the same, as this would limit the long term damage to their bodies. I have touched on this topic in my payoff matrix but I didn't include it into my actual model. (Eber & Nicolas, 2008)

The research paper "On Cheating and Whistle-Blowing" was written in 2003 as there were many big cases of whistleblowing in 2002. Yet this area lacked economic literature that properly reflected sports and their subsequent models. Their game consists of two players that choose between behaving legally and illegally, while there is a third player (controller) who chooses between testing or not testing. Cheating gives the player a clear advantage and the probability that he would win increases. What makes this special is a stage after the competition where the loser can whistleblow and tell the controller if he thinks the winner cheated or not. This is as testing is usually expensive, so the controllers prefer to not test everyone. They found that as long as the tests are reliable, this added stage compared to the base model improved the efficiency of the controllers and helped prevent doping at higher levels. I find this very interesting as this could be used in weightlifting as well, as the lifters would have the best

idea of whether they think their competitors are doping or not. However, most high-level weightlifters are tested very consistently so I think it won't have the same level of impact as depicted. (Berentsen, Bruegger, & Liuertscher, 2003)

The research paper "Economics of Doping" proposes a ranking based punishment system as the International Olympic Committee (IOC) is still struggling with catching cheaters and preventing them from doping. Their model has two athletes that simultaneously choose whether to use performance-enhancing drugs or not right before their competition. They are then tested randomly by the organizers after they are done competing. They found a problem with the IOC's regulations as they do not adjust based on the individual, and they don't provide enough incentives for players not to cheat. They found that their punishment ranking system depending on whether it was the winner or loser would be more cost-effective as there would be less testing, and it would decrease the need of increasing the punishment. Their solution was a diary where the athlete is to record all the drugs they take, and they are then tested for the substances that aren't mentioned in the diary. This is an interesting take on the punishment side of the equation and I believe better testing strategy in weightlifting could make staying innocent the equilibrium instead of the other way around. (Berentsen & Aleksander, 2002)

The research paper "Doping in Elite Sport" focused mainly on the fans/customer's response to doping and what the general consensus is. Instead of a traditional game model, this paper used real feedback from over 7 500 people to collect data on their thoughts. They asked for their opinions on certain substances in "grey" areas as well as the involvement of sponsors for these doping athletes. They were also curious about the level of punishment they think these athletes should receive for doping. They found that while the overwhelming majority was against true performance-enhancing drugs like steroids and EPO, they had mixed reviews towards "grey" level areas like medicine and high-altitude chambers. They also found that these responders supported strict punishments from sponsors towards these cheating athletes, as well as the organizations that haven't made the effort to catch them. This was a unique paper compared to the others I have read and it backs up the NE in my model very well. The data shows that the more customers or fans care about maintaining a "clean" sport, the more likely there is going to be a doping-free equilibrium. (Solberg, H.A., Hanstad, D.V., & Thoring, 2010)

The paper "Corruption in Olympic Sports" was mainly on match-fixing, bribing, and other kinds of purposeful cheating in sports. Similar to the last paper, they also focused on collecting data and making sense of them. They sent out a survey to 5 500 german Olympic athletes, of which 425 had responded. They asked them a series of questions on whether or not they have been involved or witnessed manipulations, or some other kind of rigging/match-fixing. They found that only 8% of athletes have been asked or participated in match-fixing throughout their careers. Data also showed that over 30% of athletes have confessed to attempting to influence a referee's decision, however, only about 5% was "directly" involved in the attempt. In conclusion, the amount of rigging or manipulation at the highest level of sports isn't extremely high. This showed some interesting data on match-fixing, a topic that I haven't touched on in my own paper. Nonetheless, it is quite difficult to manipulate the results in weightlifting as the lift attempt is broadcasted around the world, and could be reviewed by any passionate fan for years to come. So if all the referees were bribed and jointly made a bad call, it would be fairly easy to spot. (Frenger & Monika, 2019)

In the research paper "But Everybody's Doing It", they studied the effects of peer pressure on students and how it might influence their behavior to be dishonest. The game model used is very similar to the one from "Crime and Punishment in the Classroom". There are two students and they choose whether to cheat or play fair. They also decide the level of effort they put into studying while the professor decides the effort for detecting any cheating. They then added another layer for peer effects, where the player would cheat if and only if his classmate also cheats. Their game has the moral cost of cheating decreasing as your classmate does it too, which is what they then found the equilibrium for. They found that the better the cheating technology and lack of effort there is, the more likely it is for cheating to be the equilibrium. This is another paper that could be used to back my own findings from my model. By making the cheating technology better, it obviously gives more of an incentive to cheat and put in less effort. Although they did also find that decreasing the size of the class would take away some incentive to cheat, sadly, this does not apply for weightlifting as it's hard to limit the number of competitors. (Griebeler, 2019)

The research paper "Nobody's Innocent" was a very important paper for me as it acted as a template for my own research and model. They studied the role of the customer in these doping scandals and how they could have a huge influence as well.

Their model had three players, athletes > organizers > customers. Each player has two options, for the athlete that is to either stay clean or dope. For the organizers, it is to test or not test, and for customers, it is to either stay or

leave. For their base model, there was an information set surrounding all the cases except the tested dopers. This meant the customer now had four options: stay for both, leave for both, stay/leave, or leave/stay. Since these imaginary organizations valued money over morals, their top priority was always for customers to stay, which meant they would purposefully not test athletes as customers will then lack the motivation to leave. This is why their first nash equilibrium was for athletes to dope, organizers to not test, and for customers to stay.

However, not all hope is lost. Their second model is Pareto efficient and has a changed information set as well as new payoffs. This allowed for a doping-free equilibrium. What was important about this model was that the customers were now "informed", and they demanded to see a test or else they would leave. This dragged the tested, clean athletes out of the previous information set and gave customers now a three choice combination. Nevertheless, doing this made testing for dopers the organization's priority which allows for a clean sport. This supports their hypothesis that customers who leave after a doping scandal does the opposite of what they are hoping for and further pushes the organization to not catch dopers.

Although my paper took some inspiration from their game and conclusion, there are a few crucial differences. While "Nobody's Innocent" game model was for sports in general, I based my model specifically on weightlifting. This changes the test/no test to keep/show, which I will later extend on in the next section. I also used a different method for the payoffs, as I felt their 1-8 ranking didn't make sense in my scenario as there are fewer options. I will also talk more about exactly how I got my payoffs in the later sections. (Buechel & Berno, 2016)

After looking at these 7 research papers on the various aspects of cheating, there are a few general takeaways and conclusions that could be made. The more effort the moderator/referee puts into testing and trying to catch the cheaters, the higher the chance that the incentives would be lower for cheating. It could also be lowered with community efforts like whistleblowing after competitions, pacts/charters between athletes, and trying to decrease peer pressure. The survey-based research found that match-fixing or bribing at the highest level is relatively rare and few Olympic athletes admit to "direct" manipulation. The data also showed that an overwhelming majority of fans detest performance-enhancing drugs and support stricter punishments from sponsors and organizations. Which links well to the game that showed firm and modified punishments being a great way to prevent cheating. This data also supports both the NE in my own paper as well as the one in Nobody's Innocent, where increased customer awareness and concern would shift the favor for a doping-free equilibrium.

3. Game Model

When we look at professional sports, we see this huge, intricate, and complex net of connections that all tie in together to form the essence of the sports we love. From the athlete and coaches to organizations, management, and politicians, as well as the customers and passionate fans who watch the sport, there are dozens of players that could be considered. As you've already heard the horror stories of Ajan and his corruption, I wanted to see how these incentives could be changed so that doping would no longer be the equilibrium.

So for my model, I simplified it down to the three I thought was the most important. Athletes, Management, and Customers. The athlete has two choices, to dope or to stay clean. Doping is defined as the act of purposefully injecting or taking drugs for the sole purpose of enhancing their performance. This gives them a clear advantage over their competitors and increases their chances of winning a Championship or Olympic medal. However, there are also long term impacts on their bodies that could severely affect their health in later years. As well as major penalties if the athlete was to be caught in a drug test. But If the athlete chose to stay clean instead, and so does his fellow opponents, he would earn the normal salary + endorsements and sponsorship money but will have a significantly lower chance of winning a medal.

Management also has two choices, to tell or keep. Tell is defined as showing the athlete's drug test to all the customers and organizations by posting it publicly, while keep is simply keeping the tests buried or hidden from the public's eye. The reason I didn't have a test/no test stage is because athletes at the highest level are consistently tested year after year, especially if they want to compete in the Olympics. Knowing that a small percentage of athletes do successfully avoid or fake these tests, I built that possibility into the payoffs for the athlete.

This management could be compared in the real world to the IWF (International Weightlifting Federation), as they have many different financial incentives that I am trying to model when they choose which athlete's test they should reveal.

Last but not least, customers also have two choices, stay or leave. To stay is to continue watching games, competitions, and showing their support for the management/organizations as well as the athletes. While leaving is simply abstaining from any viewership of weightlifting material that could make a profit for the management. Customers would choose to do this if they feel that the organization isn't putting in enough effort into detecting

cheaters and promoting a cleaner version of the sport. In the real world, this player could represent the sponsors that pay for venues and competitions, the media that broadcasts and analyzes these competitions, and the passionate fans that continue watching the sport. The happiness of customers is very important for the management as a lack of viewership could mean less profit, which then leads to the lack of ability to host events and sufficiently reward the athletes.

Since this is a sequential game, first the athlete decides whether to dope or not. Then the management sees their results and decides to either keep or show these results. Finally, customers decide if they want to leave or continue supporting the sport. There is an information set surrounding the branches where the management keeps the results as the public wouldn't know the difference between whether these athletes are clean or not.

Both the athletes and management only have two strategies each. For athletes it's { Dope, Clean } while for management it is { Tell, Keep }. Whereas customers have a total of 8 strategies, as there are 3 individual decisions to be made for each branch, courtesy of the information set in the middle. The customer's strategies are { SSS, SLS, SLL, SSL, LSS, LSL, LLS, LLL }. The first letter would be the action after a scandal, the second one would be if no information was shown (information set), and the third if it was a positive test with no controversy. The S stands for Stay and the L for Leave.

In our game model, the first assumption is that the strategy is SLS, where the customer would only leave in the case of being in the dark, when the organization chose to hold back and not release the test results. The second assumption was that if management was to suspend dopers, customers would support instead of protest management. If these assumptions weren't the case, management would prefer to keep doping cases secret so that profits wouldn't deteriorate.
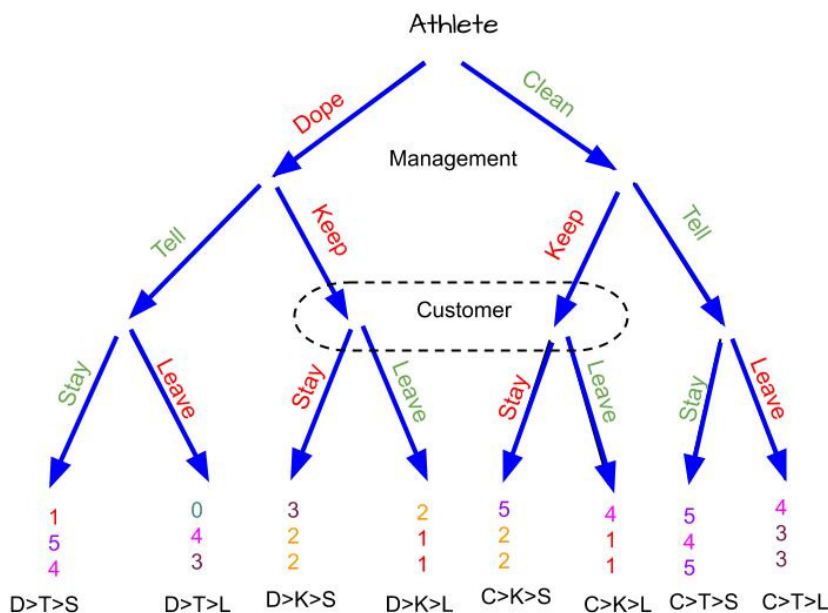
4. Payoffs

Payoffs are very important for a game model as they give a quantitative form for each decision the player makes. And through logic as well as these numbers, I am able to calculate the nash equilibrium of my game.

As you can see in the model above, our payoffs are quite different compared to the ones found in ''Nobody's Innocent''. They aren't ranked from 1-8, and some decisions have the same payoffs. Since my model is based entirely on weightlifting, I believed the 1-8 didn't make sense and couldn't translate to the real world. Although

some assumptions were made on the cost of cheating/staying clean, the below sections represent a relatively realistic model on the best decisions for the 3 players.

An athlete is a very special player in this game, as their choice is the first one made and affects all the other players, especially the management. However, each athlete's choice is also influenced by other athletes, which is shown below in the two grids.

Scenario I: My opponent is not using drugs and has decided to compete fairly. The athlete now has two options.		**Scenario 2:** My opponent is using drugs and is actively trying to avoid getting caught. The athlete still has two options.	
Payoff 1		**Payoff 3**	
The athlete also decides to not use drugs and compete fairly, which makes it an even playing field for everyone involved.		The athlete still decides to not dope and compete fairly, which makes it an uneven playing field. However, there is now a chance of getting cut if the opponent isn't caught by management.	
This is the value of being a competitive weightlifter ranked in the top 30s in the athlete's weight class. The money is earned through sponsorships, government programs, potential podium finishes, etc.	**$1 million**	The value of being a competitive weightlifter for one year is still the same. $1 million * 85%= (Value of Competing * Chance of Opponent getting caught)	**$850 000**
Since both athletes aren't using drugs, there is no risk of being cut/fired for being uncompetitive in their weight class. And since the athlete is clean, there is no chance of being caught on drugs.	**$0**	Since the opponent is now much more successful, there is a risk of being cut/fired for being uncompetitive in their weight class. However, unlike getting caught for doping in payoff 2, there is no punishment. Simply a lack of money/salary from sponsorships and the organization.	**-$0**

		$0 * 15%= (Value of being cut * Chance of opponent not getting cut)	
Total expected payoff:	**$1 million**	Total expected payoff:	**$850 000**
Payoff 2		**Payoff 4**	
The athlete decides to use drugs and tries to avoid getting caught. This makes it an uneven playing field and gives them an unfair advantage over his opponent.		Since his opponent is doping, the athlete decides to dope as well. This makes the playing field even again.	
Since the athlete is on drugs, and his opponent isn't, it gives him a huge advantage and a much higher chance of winning the championship for his weight class. The value of winning is much higher than just competing as most countries reward podium finishes and more sponsors would be attracted. $5 million * 15%= (Value of winning the championship * Chance of not getting caught)	**$750 000**	Since both these athletes are now on drugs there is no competitive advantage for any of them. The value of competing stays the same. $1 million * 15% (Value of Competing * Chance of not getting caught)	**$150 000**
However, after recent reforms in 2020, stricter penalties and better testing technology has made it easier for the organization to test and find cheaters. Dopers can now be banned for years and their country could be	**-$850 000**	Similar to payoff 2, there is now a punishment from sponsors and the organization for doping if the athlete was to be caught. -$1 million * 85%=	**-$850 000**

banned from competing as well. Some sponsors even demand money back if the athlete was caught using and they could receive severe backlash from the media. -$1 million * 85%= (Penalty for Cheating * Chance of getting caught)		(Penalty for Cheating * Chance of getting caught)	
Total expected payoff:	**-$100 000**	Total expected payoff:	**-$700 000**
As you can clearly see, earning a million is a much better payoff than losing 100 thousand. This is why the payoff would be higher for staying clean compared to doping in the scenario that their opponent is clean.		As the payoffs show, staying clean even when your opponent is doping is still the better move as 800 000 > -700 000. These two scenarios show how the better move is to always be clean, no matter if your opponent is doping or not.	

Now that these two scenarios showcase why staying clean has a higher payoff than doping, let's dive into why our payoffs are ranked the way they are.

First, the general assumption is that no matter what branch of decisions it was, the customer leaving's payoff would always be 1 lower then if they had stayed. Since customers leaving would always result in less money for the organization, which in turn results in less pay for the athletes.

Let's start with the worst branch, D > T > S/L. The payoff is 1 for stay and 0 for leave. It is quite obvious why these would have the worst payoff for the athletes. Loss of sponsorship, year-long bans, and even potentially being kicked out from their national organization would mean the end of a career for most of these athletes.

The next branch is D > K > S/L. The payoff is 3 for stay and 2 for leave. While this does share an information set with C > K > S/L, the payoffs are worse as doping has some terrible effects on the body. An interview with an anonymous Thai weightlifter said she grew a beard and started sounding like a man! Some other serious side effects include insomnia, anxiety, and an increased risk of stroke, heart attack, etc. Nonetheless, these payoffs are still better than D > T > S/L as they would still have sponsorships and a salary from their national organizations.

The next two branches C > T/K > S/L have the same payoffs no matter keep or tell. The payoff is 5 for stay and 4 for leave. The reason these are the same is as the athletes aren't affected by the choices the customer made for the information set, the management takes the blow for that instead. Since their salary and employment would have remained the same, their payoffs are the same as well. The reason why these two branches have the highest payoffs was made quite obvious by the two scenarios showcased above.

First, the general assumption for management is that after the big McLaren scandal in January 2020, the new board members want to catch dopers in pursuit of a cleaner sport. As most of these newer representational members are from western countries with a historically lower count of doping scandals, it makes logical sense that this is now the new direction for the management. And since customers won't leave when dopers are found, their first priority is now to find these cheaters instead of hiding them.

The general assumption is similar to that of the athlete. No matter what branch of decisions it was, the customer leaving's payoff would always be 1 lower then if they had stayed.

Opposite of the athletes, the branch D > T > S/L has the highest payoff for management. The payoff is 5 for stay and 4 for leave. After all these big in-depth documentaries and reports on the corruption of the IWF (International Weightlifting Federation), the new leaders are trying their best to garner more positive interest towards their sport. Stopping systematic doping in certain countries and catching individual lifters would be the best way to show the customers that they are putting in a lot of effort for the advancement of this sport.

The next branch C > T > S/L also has a high payoff for management. The payoff is 4 for stay and 3 for leave. While it isn't as glorious as banning a country for 3 years on doping charges, the majority of the cases would fall into this category. After the new Olympic qualification system came out, it makes finding dopers much easier and makes life much harder for those trying to cheat. The qualification requires you to compete at least 6 times during the 3 6-month periods, and at least one time in each period. This requires athletes to be tested far more often instead of disappearing for 4 years and showing up just for the games. This payoff is still higher than the two branches in the information set as the customer would be satisfied with the clean test results.

The next two branches have the same payoffs as they are both in the same information set. Branch D > K > S/L and C > K > S/L. The payoff is 2 for stay and 1 for leave. Customers are now willing to leave if the management doesn't show all the drug tests. So the end result is the same if they keep these tests, no matter if the athlete is doping or clean. Which is why the payoff is the same for these two branches. Now, the reason why this has the lowest payoff is quite obvious. After these scandals, customers would be automatically suspicious if no test results were shown for certain athletes, and would be likely to stop watching. This results in a drop in income, pulling out or lack of sponsorships, less exposure from media, etc.

The general assumption made for customers is that they would prefer to stay rather than leave, as they are passionate fans of weightlifting. However, in the absence of doping tests for athletes, they are willing to leave and stop watching as they believe the sport is no longer clean.

While these two branches are different, there are some similarities in payoff which is why I will talk about them together. The branch C > T > S/L has a payoff of 5 for stay and 3 for leave, the highest payoff for the customer. The branch D / T / S/L has a payoff of 4 for stay and 3 for leave. While customers wouldn't leave after the management uncovers cheaters and dopers, they would still have a higher payoff from seeing clean tests. This is as fans are usually happier when they see that the weightlifting idols that inspire them are tested as clean and not dirty.

However, I believe the payoff for leaving is the same as they both left even when the management was honest, so the issue is one on the customer's end and not the organization's fault. While the assumption is usually that leaving would have a payoff of one lower than staying, it didn't make sense why there would be a difference in leaving between these two branches.

The final branch is the information set of D > K > S/L and C > K > S/L. The payoff is 2 for stay and 1 for leave. These two have the same payoffs for the customers as they have no clue whether or not the athlete was doping or not. Since the organization decided to keep the information, the customers would either stay and continue watching, but suffer from guilt and a lower payoff as they know the competition is biased and unfair. Or they have their worst payoff of 1 as they no longer trust this federation and have left because of their direct action.

5. Nash Equilibrium

After carefully observing the payoffs and the logical makeup of the game, I have found the Pareto efficient subgame perfect nash equilibrium to be the branch of C > T > S (Clean > Test > Stay). This is where athletes choose to stay clean, the management chooses to make the tests public, and the customer decides to stay.

As shown in "Nobody's Innocent", ironically, when customers leave after negative tests it actually boosts the amount of hidden doping in their respective sport. However, when customers demand to see tests revealed for all athletes instead and cheer on the management for uncovering or popping dirty athletes, it makes a doping-free equilibrium possible. This exact mindset of the customers was what I modeled in my game. By having only one information set around the tests that were kept, it allows customers to decide to leave only in the absence of these drug tests. This decision shows the management that these customers are now informed and prioritize having a clean sport over everything else. The move forces the hand of the management, by making what previously had the worst payoff to now having the best one. Although the athlete makes his decision first, what the customer has indirectly done is make the payoff for staying clean significantly higher than that of doping. This was proven in our two scenarios inside the grid.

The best part of this branch is that for athletes and customers, this is the highest payoff they could have achieved. For athletes, they now have the same competitive advantage as everyone else while not needing to inject

themselves with increasingly harmful substances.

For customers, they can now see proof that all these athletes are competing fairly and equally with each other, with hard work being the only decider of the winner. Having a cleaner sport will also promote better technique and training styles, as well as the overall development of the sport instead of a chemistry competition to see who could make the most potent drugs. This will certainly make fans happier as well as inspire more people to try this sport out.

Although the management could have achieved a slightly higher payoff if they were to catch a cheater, they have nothing to complain about as their profits will only continue to rise as Olympic Weightlifting stands itself out as a model of clean and tested sports at the highest levels. For the reasons stated above, this is why Clean > Tell > Stay (S, L, S) is the nash equilibrium of my game.

6. Nash Equilibrium Discussion

Since critics who read the literature review and the doping equilibrium would certainly have some inquiries, the sections below answers the most commonly asked questions on doping in weightlifting.

<History / Advancement of the Sport> As most fans look back into their history books or watch videos on lifters 30 or 40 years ago, they might notice that the world records haven't gone up significantly, and in some cases, even went down! In the early stages of weightlifting, right around when doping was first proven to be very effective for strength training, it was made quite clear that everyone on the stage was on some sort of performance-enhancing drugs. Quite similar to the "golden age" of bodybuilding when big names like Arnold Schwarzenegger were competing. Fans look at these legends and deduce that modern weightlifting has gone down in terms of form, technique, and training styles as the records haven't been pushed significantly higher (Note 2). However, I believe that the exact opposite is true. Weightlifting has advanced as a sport as a whole. Although doping was still somewhat rampant as shown by the whole Ajan/McLaren mess, the amount and types of drugs athletes could use has gone down significantly. Which makes the fact that we are still able to hit the same numbers much more amazing. Although the improvement is slight, it is slow and steady as we gain a better understanding of the best way to train for natural athletes. Nonetheless, I still believe these historical world-shattering lifts deserve a place in our history books for the pure grit and sacrifice it took to get there.

<Cat and Mouse Game> As seen in our model, a doping-free equilibrium is clearly possible with the right incentives for the right people. Sadly, some sort of doping will always occur on some level or another. It's an infinite cat and mouse game as athletes and coaches find new drugs or ways to hide usage, and the testing organizations continue trying to catch these cheaters. But despite all this pessimism, what's most important is for customers to understand and be aware of what is happening. Once customers can become truly suspicious of the unposted drug tests and revoked bans, that is when true change can also begin to occur.

<Why Rules Are Important> Haters might say, just erase all the rules. Let them dope it out and see what the human body is truly capable of. While there are some positives in that, with huge mind-numbing lifts being usually more entertaining, there are several reasons why this shouldn't be the case. The most important one being that many third world countries will likely start with children in their child-teenage years and put them on a substantial amount of drugs. While a very small 1% might adapt and survive, and maybe even one day become an Olympic champion! As well as enjoy the glory and wealth he has worked hard for and deserve. All the other 99% will simply fall into the shadows, with a lifetime of medical bills trying to undo the damage done to their bodies. The lack of education they had received in their youth could also give them a severe setback for finding jobs or a new line of work. Another reason is that finding out what humans can do when pushed to their natural limit is just as amazing, if not even more then having everybody be dependent on chemical enhancements. This statement will hold even more ground in the future as cybernetic enhancements begin to become commonplace, and soon we might as well watch robots compete instead of us!

7. Conclusion

In our research paper, our main goal was to see if a doping-free equilibrium is possible for top-level international lifters in the sport of Olympic Weightlifting. This exploration was motivated by the massive scandal revolving around Ajan and his usage of drug tests, which paved his way to the top. But now that his corruption has been made public, a new president and board have been put in. This change makes the competitive landscape vastly different than what it used to be. With new management catching dopers left and right while supporting natural lifters, I believe a new game model could be made with fresh payoffs and game assumptions.

The game model is a three-player sequential game, consisting of the athlete, management, and customers, each with two choices. The athlete chooses between doping and staying clean, management between showing or hiding

the results, and the customer between leaving or staying as a supporter/fan. While the first two both have two obvious strategies, the customer had eight as there was an information set surrounding the hidden tests. The first major game assumption I made was that customers would leave if management released no information at all. The second was that if management was to suspend dopers, customers would support instead of protest management. If these assumptions weren't the case, management would prefer to keep doping cases secret so profits wouldn't deteriorate.

I then studied realistic rules and scenarios to generate the most accurate payoffs possible. With all this information in hand, I inferred a logical explanation of the N.E. that was Pareto efficient for everyone. The Nash equilibrium I found was Clean > Show > Stay (S, L, S). This deduction makes the most sense as athletes would have the same competitive advantages as everyone else, without the need to sacrifice their bodies through the usage of drugs. Management would also be happy as their profits would continue rising while they became a role model for other sports to follow. And last but not least, customers would be content with the continuous improvement of technique and the satisfaction of knowing their favorite athletes are natural.

This reasoning was how I came to the conclusion that a doping-free equilibrium is not only possible but increasingly achievable. Fans are becoming more aware, and organizations are adapting along with them. This change could push the sport of Olympic Weightlifting to new heights in every sense of the word.

References

Berentsen, A. (2002). The Economics of Doping. *European Journal of Political Economy, 18*(1), 109-127. https://doi.org/10.1016/S0176-2680(01)00071-4

Berentsen, A., Bruegger, E., & Liuertscher, S. (2003). On Cheating and Whistle-Blowing. IEW - Working Papers 153. Institute for Empirical Research in Economics, University of Zurich. https://doi.org/10.2139/ssrn.419941

Berkowitz, B., & Meko, T. (2016). Stronger. Faster. Longer. And Higher. *The Washington Post*, 28 June 2016, Retrieved August 5, 2020, from www.washingtonpost.com/graphics/sports/olympics/doping/

Brown, P. (2008). The Doping Game: Payoffs That Make Cheaters Into Losers. *Scientific American*, 2 Apr. 2008, Retrieved August 5, 2020, from www.scientificamerican.com/article/the-doping-game-payoffs/

Buechel, B. et al. (2016). Nobody's Innocent: The Role of Customers in the Doping Dilemma. *Journal of Sports Economics, 17*(8), 767–789. https://doi.org/10.1177/1527002514551475

Eber, N. (2008). The Performance-Enhancing Drug Game Reconsidered: A Fair Play Approach. *Journal of Sports Economics, 9*(3), 318–327. https://doi.org/10.1177/1527002507308109

Frenger, M. et al. (2019). Corruption in Olympic Sports: Prevalence Estimations of Match Fixing Among German Squad Athletes. *SAGE Open*, July 2019. https://doi.org/10.1177/2158244019865361

Griebeler, M. (2017). Crime and Punishment in Classroom: A Game-Theoretic Approach for Student Cheating. *Rev. Bras. Econ., 71*(1), 43-65. https://doi.org/10.5935/0034-7140.20170003

Griebeler, M. (2019). "But everybody's doing it!": a model of peer effects on student cheating. *Theory and Decision, 86*(2), 259-281. https://doi.org/10.1007/s11238-018-9680-x

IWF Executive Board Appoints Richard H. McLaren to Lead Investigation into Ard Allegations. *McLaren Global Sport Solutions*.

Kent, D. (2020). McLaren Report - Full Details. *Weightlifting House*, 5 June 2020. Retrieved August 5, 2020, from www.weightliftinghouse.com/2020/06/05/mclaren-report-full-details/

McLaren, R. H. (2020). *Independent Investigator Report to the Oversight and Integrity Commission of International Weightlifting Federation*. Retrieved from https://www.mclarenglobalsportsolutions.com/pdf/FinalReport_IWF_June6_2020.pdf

Oliver, B. (2019). From Doping Basket-case to Olympic Role Model - How Weightlifting Rescued Itself. In D. Mackay (Ed.), *Inside the Games*. Retrieved August 5, 2020, from www.insidethegames.biz/articles/1084471/how-weightlifting-saved-itself

Oliver, B. (n.d.). ITA Begins Investigation into Covered-up Weightlifting Doping as WADA 'appalled' by Evidence. *Inside the Games*, 15 June 2020. Retrieved August 5, 2020, from www.insidethegames.biz/articles/1095345/wada-mclaren-weightlifting-statement-2

Oliver, B. (n.d.). Senior Thai Official Named in McLaren Report. *Inside the Games*, 10 June 2020. Retrieved

    August 5, 2020, from www.insidethegames.biz/articles/1095179/yodbangtoey-denies-corruption

Solberg, H. A., Hanstad, D. V., & Thøring, T. A. (2010). Doping in elite sport - do the fans care? Public opinion on the consequences of doping scandals. *International Journal of Sports Marketing and Sponsorship, 11*(3), 2-16. https://doi.org/10.1108/IJSMS-11-03-2010-B002

Notes

Note 1. Bonnie Berkowitz and Tim Meko, "Stronger. Faster. Longer. And higher", Washington Post, 6/28/2016. https://www.washingtonpost.com/graphics/sports/olympics/doping/ acc. 8/3/2020.

Note 2. In my paper, I continuously reference technique and form in weightlifting. The definition of technique or form is the most efficient way to perform the task for the specific athlete in question. In other words, there is no such thing as perfect technique, as it should be adapted depending on the athlete. However, there are some common things to look for when someone talks about having good form. Being fluid, smooth, fast, and snappy are all great qualities in weightlifting, which is all in full display if you were to watch an event like the Olympic games. The best way to describe it by comparing it to a golf swing. As anyone who has played golf could tell you, a beautiful hit should feel effortless and completely smooth, and not lethargic with hesitation.

Copyrights