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Technology in Major League Baseball: 2017 Houston Astros, Prisoner's Dilemma, and Behavioral Solutions

Spencer Kinyon
spencer.kinyon@uconn.edu

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Student: Spencer Kinyon

Thesis Advisor: Professor Thomas Miceli

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Introduction:

In the 2017 season, the Houston Astros used a technology that deciphered the signs of the opponent's team catcher and would inform the Houston Astros hitter what pitch would be thrown by the pitcher. It is difficult to determine the exact benefits that the Houston Astros gained from this technology. However, the Houston Astros were the 2017 World Series Champions, the team had the lowest number of strikeouts, and the highest team batting average, on base percentage, slugging percentage, and on base plus slugging percentage for any team in the 2017 season (ESPN, n.d.). The use of the technology and these team statistics and World Series championship could be correlated in a spurious relationship, but that is not likely to be the situation. It is more likely that the technology gave the Houston Astros a significant advantage that translated into better offensive performance, more wins, and a World Series championship.

The purpose of this paper is to provide an economic analysis for why the Houston Astros or any team would use what is considered an *illegal technology* to gain an advantage and win baseball games. Due to the existence of technology, baseball is no longer a game that is won strictly on the basis of talent, but it is a game that is won on the basis of talent and technology (whether it be legal or illegal). The Houston Astros acted rationally in the team's pursuit of its own self-interest to win the 2017 World Series. The existence and relevance of bounded rationality dictate that the Houston Astros did not know the exact probability of detection, victory, or penalty. However, the team understood the benefits associated with victory were greater than the costs associated with being caught. Through Major League Baseball (MLB) limiting fines to $5 million, the league has created a system of perverse incentives for teams to use illegal technology. In the 2017 season, the average salary for a MLB player was $4.45

million (Gough, 2019). For a little more than the cost of the average player, the Houston Astros were willing to use an illegal technology to distort the game of baseball for the team's advantage.

Due to the existence of illegal technology, MLB teams are (or will be) stuck in a prisoner's dilemma. Every team now has a choice about whether or not to use illegal technology in a game. If both teams do not use the illegal technology in a game, then that is the optimal solution. However, if one team uses the illegal technology in a game, and the other team does not use the illegal technology, then the team that uses the technology has a clear advantage. As a result, both teams have a dominant strategy to use the technology and this results in a Nash sub-optimal equilibrium. Both baseball teams would then use the illegal technology and the benefits of the technology for one team would nullify the benefits that the other team would receive. Baseball teams will be caught in this suboptimal equilibrium because of the perverse incentives in MLB and the inability or even the unwillingness of the league to properly deter this strategy. While cooperation is necessary among teams to escape this prisoner's dilemma, MLB must remove the cap that is placed on fines in order to further deter use of illegal technology.

Additionally, MLB must allow for the system by which catchers indicate pitches to evolve. With the existence of illegal technology, the defense of baseball teams has become irrational. If the defense of a baseball team wants to prevent the other team from scoring runs, then the team would logically take actions to prevent the opposing team from doing so. The preferences of the defense are as follows: (1) indicate signs to the pitcher without the opposing team knowing or (2) indicate signs to the pitcher with the opposing team knowing. Currently, when the catcher indicates signs to the pitcher, the opposing team is able to use the technology to decipher those signs. The status quo bias provides a useful explanation for why teams have not

made more of an effort to change this method of communication. MLB must alter the behavior of the defense, so the defense is willing to choose a strategy to indicate signs to the pitcher without the opposing team knowing what pitch will be thrown. MLB teams may also have not adopted innovations that are capable of "outsmarting" the technology. The book *Nudge* by Richard Thaler and Cass Sunstein offers useful and creative advice on how MLB could change the behaviors of teams and players.

In this paper, the first section is a literature review that is broken into three sections: psychology background, economics background, and sports history background. The second section explains the structure and economic model for baseball in the 20th century without the use of technology. The third section explains the structure and economic model for baseball in the 21st century with the use of technology. The fourth section explains the economics of penalties in MLB, and the cost-benefit analysis that teams do to understand whether or not they should use illegal technology. The fifth section applies the economics of penalties and cost-benefit analysis to explain the behavior of the Houston Astros in the 2017 season. The sixth section explains the prisoner's dilemma that is created because of the use of illegal technology in MLB. The seventh section explains how MLB teams can escape the prisoner's dilemma to restore uncertainty of outcome to games.

I. Literature Review

This paper provides an economic and interdisciplinary perspective on the Houston Astros Cheating Scandal. As a result, there are three subsections to the literature review. The first

section provides a psychology background, second section provides an economics background, and third section provides a sports history background.

A. Psychology Background

Tversky and Kahneman (1974) explain three heuristics (representativeness, availability, and anchoring) that impact how humans make decisions and lead to common biases. The representative heuristic is "employed to when people are asked to judge the probability that an object or event A belongs to class or process B" (Tversky and Kahneman, 1974, 1131). As a result, this heuristic causes humans to have "insensitivity to prior probability of outcomes" (Tversky and Kahneman, 1974, 1124) and "insensitivity to predictability", which impacts how predictions are made based on information that is not correctly interpreted. The availability heuristic is "employed when people are asked to assess the frequency of a class or the plausibility of a particular development" (Tversky and Kahneman, 1974, 1131). In decision-making, humans have difficulty with "retrievability of instances" and "imaginability", which causes us to focus on rare events, rather than common events. (Tversky and Kahneman, 1974, 1127). The anchoring heuristic is "employed in numerical prediction when a relevant value is available" (Tversky and Kahneman, 1974, 1131). Through these heuristics and others that researchers have described, humans are fallible in decision-making and our mental processes lead us to make decisions that have systematic errors and are not viewed as "rational".

B. Economics Background

Rationality is defined as pursuing an objective in the best and least cost way. Furthermore, rationality is when an individual has a set of preferences that are ranked, they

always adopt, and make choices based on. Individuals are able to access perfect information and perfect knowledge in order to make the best decisions. However, economist Herbert Simon articulated that individuals are not capable of behaving in this "rational" way. Due to the impossibility of processing all information and knowledge, humans have a limited ability to be "rational." Simon defined the concept "bounded rationality" to describe decision-making with limited information and knowledge, and the reliance of individuals on our own heuristics and shortcuts. Bounded rationality is closer to describing how humans actually make decisions compared to rationality and the belief that humans have all of the abilities and resources to make a rational decision.

William Samuelson and Richard Zeckhauser (1988) identified the existence of the status quo bias and its pervasive impact in the tendency of people to remain with the status quo under uncertainty. The authors argued that the status quo bias occurs not because of rational choice theory, but due to the psychology of humans. "The stronger the individual's previous commitment to the status quo, the stronger the anchoring effect" (Samuelson and Zeckhauser, 1988, 41). As a result, the status quo bias forces people to be in a sub-optimal position without them even realizing that they are acting against their own self-interest.

In a prisoner's dilemma, there are at least two players who have at least two strategies to choose between that have either optimal payoffs or sub-optimal payoffs. The players will always choose the dominant strategy that results in sub-optimal payoffs for both of them. In any prisoner's dilemma, the suboptimal outcomes are always inferior to the optimal outcomes. The Nash Equilibria occurs when both players choose their dominant strategies that results in a suboptimal equilibrium.

Kjetil K. Haugen (2004) identified the existence of the prisoner's dilemma with doping in cycling. Players have a choice about whether or not to use performance-enhancing drugs (PEDs). However, players are caught in a prisoner's dilemma about whether or not to use PEDs, even if they are uncertain about the effects and advantages of the drugs (this is ignoring the moral opinions of some players). J.C. Bradbury (2007) wrote about the existence of the prisoner's dilemma in baseball with PEDs. Bradbury applied the prisoner's dilemma to understand the incentives of players and why they would use them to potentially benefit in the labor market. Baseball Hall of Fame Pitcher Bob Gibson once stated "I'm happy they [PEDs] weren't available (when he played), because if I knew somebody else was doing it and appeared to be getting an edge, I think I would have been tempted." Despite being one of the greatest pitchers, Bob Gibson would have been willing to use PEDs if it meant that he could potentially match the advantages that his opponent gained from their use of PEDs. Therefore, both Bob Gibson and his opponent would have been caught in a prisoner's dilemma of choosing the dominant strategy to use PEDs and receive suboptimal payoffs instead of choosing to not use PEDs and receive optimal payoffs.

Jolls, Sunstein, and Thaler (1998) provide a framework for how economists can consider psychological implications in the field of law and economics. The authors argue that individuals act with bounded rationality because "bounded rationality as it relates to judgement behavior will come into play whenever actors in the legal system are called upon to assess the probability of an uncertain event" (Jolls, Sunstein, and Thaler, 1998, 1480). Due to humans not being perfect calculators, they "judge the likelihood of uncertain events (such as getting caught for a crime) by how available such instances are to the mind, and this may depend on factors unrelated to the actual probability of the event." (Jolls, Sunstein, and Thaler, 1998, 1538).

Thaler and Sunstein (2003) argue that libertarian paternalism should be adopted in certain cases to promote the welfare of individuals. A libertarian is an individual who generally believes in less authoritative structure and more freedom for individuals to make decisions. Opposite to a libertarian is a paternalist, who generally believes in a more authoritative structure and less freedom for individuals to make decisions with an authoritative body "coercing" people to make the ideal choices. Libertarian Paternalism is when an authoritative body structures choices to lead people to the ideal choice, but there is no coercion, and individuals can opt out. Thaler and Sunstein outline the three approaches that libertarian paternalists could use including (1) "the approach that the majority would choose if explicit choices were required and revealed"; (2) "the approach that would force people to make their choices explicit"; and (3) "the approach minimizes the number of opt-outs" (Thaler and Sunstein, 2003, 178-179).

In the book *Nudge: Improving Decisions About Health, Wealth, and Happiness* by Richard Thaler and Cass Sunstein (2009), the authors define a choice mechanism they call "nudge" that is capable of changing people's behaviors from an individual being "irrational" to an individual being "rational". A nudge is able to change people's behavior because a choice architect changes the default choice to be the optimal choice that allows people to act in their self-interest. Choice architects are individuals who design the systems or methods through which people make choices. Choice architects would use a nudge so that the default choice is now the best decision that the individual would have made. The authors argue that nudge works because we are human and not "Homo-Economicus". Our psychological biases and inconsistencies cause our decision-making to sometimes be flawed and for us to make irrational choices. Nudge changes the default choice so that the choice is rational and is part of the status quo. Thaler and

Sunstein argue that when humans make choices, they are willing to stick with the default because of "inertia" and the "status quo bias" (Thaler and Sunstein, 2009, 85). People struggle to change from the default because it takes some amount of effort to change their behavior.

Thaler and Sunstein argue that choice architects should consider the following principles when structuring choices: "incentives, understand mappings, defaults, give feedback, expect error, and structure complex choices" (Thaler and Sunstein, 2009, 102). Choice architects must understand the incentives that are related to the choices that individuals have to make. If a consumer is clearly informed about the financial costs of a choice, then they would be willing to change their behavior. For example, Thaler and Sunstein hypothesize that a thermostat that informs the individual of the cost of raising their heat by a few degrees might be enough to get them to keep the temperature low and their electricity costs down (Thaler and Sunstein, 2009, 101). Thaler and Sunstein argue that choice architects must understand that people should understand the connection between the choices and welfare they receive from that choice. "Call this relation between choice and welfare a mapping" (Thaler and Sunstein, 2009, 94) and "Often people have a problem in mapping products into money" (Thaler and Sunstein, 2009, 95). Thaler and Sunstein argue that mapping could be improved through a system called "RECAP: Record, Evaluate, and Compare Alternative Prices" (Thaler and Sunstein, 2009, 95). RECAP would force companies to report to the consumer all associated fees, charges, interest rates, and other costs associated with an item or service. The consumer is then able to receive this RECAP report from every company they wish to potentially buy a good or service from. The consumer can then compare all of these reports and better understand the costs of the decision that they have to make. Additionally, people are prone to make errors that could have big or costly impacts. For

example, Thaler and Sunstein explain how cars are filled with "nudges", such as a light that informs the driver to turn their seatbelt on and a light that informs the driver that they need to change their oil or fill their gasoline (Thaler and Sunstein, 2009, 90). These nudges exist because we make errors, such as forgetting to put on our seatbelt or when we need our next oil change. Additionally, humans sometimes need feedback, so that they know they made a choice. Thaler and Sunstein provide the example that when people take a picture on a modern-day camera, there is still a click sound (Thaler and Sunstein 2009, 92). The reason that cameras still click, despite no longer needing film, is because people might otherwise not know if they took a picture. The click prevents people from taking several photos. Thaler and Sunstein stress the importance of "structuring complex choices", meaning that "As choices become more numerous...good choice architecture will provide structure, and structure will affect outcomes" (Thaler and Sunstein, 2009, 97). For example, when an individual is at a new restaurant with an extremely large menu, they might have a difficult time making a choice. However, if the restaurant indicates which of their dishes are the best, then the decision making process is more structured and easy for the customer.

In regards to the economics of sports, Simon Rottenberg (1956) wrote the first economics of sports paper on the game of baseball titled "The Baseball Players' Labor Market." Rottenberg identified the justification of the reserve clause to be:

> "that the reserve rule is necessary to assure an equal distribution of playing talent among opposing teams; that a more or less equal distribution of talent is necessary if there is to be uncertainty of outcome; and that uncertainty of outcome is necessary if the consumer is to be willing to pay admission to the game" (Rottenberg, 1956, 246).

This statement has become known as the uncertainty of outcome hypothesis because fans are only willing to pay money for a sports game if they are uncertain of the outcome. Despite the

reserve clause rules having changed since 1956 to only apply to the first six years of a player's career, the uncertainty of outcome hypothesis is still valid. If a fan was certain about the outcome of every game, then there is little reason for them to watch. Fans receive utility from watching a game unfold and uncertainty generates more satisfaction when their preferred team wins. While there might be some fans who pay to receive utility from watching the game of baseball even if the outcome is certain, the casual or prospective fan who wants to see a competition will not pay to see a certain outcome. Every pitch, at-bat, and play are parts of the game of baseball that are uncertain, and must be uncertain for a competition with an uncertain outcome to occur.

C. Sports Background

The central goal of MLB is to ensure that there is competitive balance in the league. Competition between teams often leads to imbalances that need to be corrected, whether this be by teams innovating, MLB instituting a new policy, or MLB penalizing a team. Standard deviation of winning percentage is often considered to be a good measure of competitive balance. If the standard deviation of winning percentage is low and close to zero, then this indicates the league is balanced and the teams are close together in terms of competitiveness. If the standard deviation of winning percentage is high, then this indicates the league may not be balanced and the teams are not equal in terms of competitiveness. Figure 1 is a depiction of the

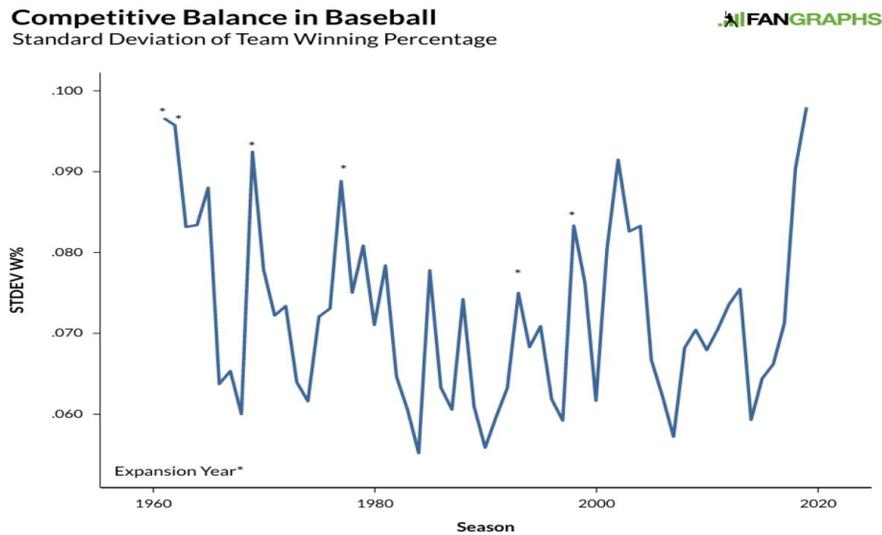competitive balance in baseball between the years 1960 and 2020.

Figure 1: (Source: Edwards 2019)

Edwards (2020) recognizes that the peaks of standard deviation of team winning percentage are associated with expansion years when new teams entered the league (expansion teams are notorious for having a poor performance in the team's first year). However, Edwards (2020) notes there is also a correlation between the rise in competitive balance at the turn of the century due to the use of PEDs. Edwards does not provide a clear reason for why competitive balance has drastically risen in the second half of the 2010s, but he speculates it is because of the existence of multiple "superteams" that have seasons with over 100 wins.

MLB has sought to ensure competitive balance in a top-down approach in various ways, such as reverse-order drafts, revenue sharing, and the reserve clause (Miceli 2019). MLB has also penalized players harmful behaviors that disrupt competitive balance. However, the penalties have a mixed history of effectively deterring harmful behavior.

MLB has been most successful at deterring players from gambling on baseball games. In the 1919 World Series, 8 Chicago White Sox players were accused of fixing the World Series for gambling bets. The 8 players were banned from MLB. No player ever gambled on a game of baseball again until Pete Rose. After it was discovered that Pete Rose had been gambling, he was banned from MLB. No player has since gambled on baseball. MLB gives tough penalties for players who gamble on baseball because when a baseball game is fixed, the outcome is no longer uncertain, and the teams are no longer fairly balanced.

The penalties on PEDs have evolved over time because the original penalties were not an effective deterrent. PEDs disrupted competitive balance because the drugs gave an unequal advantage to players who used them. From the 1980s to the early 2010s, the use of PEDs was rampant in MLB. Despite MLB cracking down on the use of PEDs and suspending players in the mid-2000s, players continued to use PEDs. It was not until MLB significantly increased the penalties did players stop using PEDs. Even with increased penalties, players still are known to use PEDs, but it is no longer as common.

Teams have also sought to correct competitive imbalances. In a chapter of *The Baseball Economist* titled "Innovating to Win", J.C. Bradbury (2007) outlines innovations pursued by MLB teams that led to that team winning games. Other teams then adopted that innovation in order to restore a competitive balance. The Oakland Athletics' front office discovered that on-base percentage was undervalued on the free agency market. The Oakland Athletics were able to do this through using technology that could analyze the performance and salaries of players. The Oakland Athletics benefited from this discovery for several seasons before other teams started to adopt this innovation. Every MLB team soon developed a front office that is capable of

analyzing performance statistics and what players should be paid. Bradbury (2007, 129) explained that a major innovation in baseball was the decision of the Brooklyn Dodgers General Manager Branch Rickey to sign Jackie Robinson and desegregate MLB. Prior to 1947, African American baseball players were blocked from playing in MLB because of racism, and no team would hire African American players. After Jackie Robinson's successful rookie year, other teams began to sign African American players.

Thaler and Sunstein (2004) discuss the existence of bounded rationality and heuristics in MLB. The thesis of their book review of *Moneyball* is that Billy Beane and Oakland Athletics acted rationally in a market, whereby many teams were acting irrationally and overpaying players. Thaler and Sunstein argue that the use of technology as pioneered by the Oakland Athletics corrected the inaccuracies of heuristics and biases that plagued baseball. For example, MLB scouts have always relied on the representativeness heuristic to understand the traits and characteristics of a good baseball player, but Billy Beane used statistics instead of the scout's biases to understand which players were good (Thaler and Sunstein, 2004, 1396-1397). Additionally, the technology and statistics that the Oakland Athletics used were around for many years, but teams had relied on their previous methods and were not willing to innovate despite it being rational to do so (Thaler and Sunstein, 2004, 1398).

The innovation of technology in MLB has been widely spread. However, MLB has always been wary of the idea that teams may use technology to steal information from other teams. The first occurrence of an illegal use of technology under MLB rules occurred when Chris Correa, an executive for the St. Louis Cardinals, hacked into the "Houston Astros' email system and analytical scouting database in 2013 and 2014" (Manfred, 2017, 1). The use of technology

imposes a difficulty for MLB to understand how much harm is done by a team that acts illegally.

Commissioner Robert Manfred noted this challenge by stating: "The type of potential

competitive harm the Astros suffered as a result of Mr. Correa's conduct is not amenable to

precise quantification" (Manfred, 2017, 2). Commissioner Manfred penalized the St. Louis

Cardinals by banning Chris Correa, giving the top two draft picks of the St. Louis Cardinals in

the 2017 draft to the Astros, and fining the St. Louis Cardinals $2,000,000 (Manfred, 2017, 3).

On January 13, 2020 MLB Commissioner Rob Manfred released a statement regarding

the Houston Astros scandal. A section of the report was dedicated to the factual findings of

MLB's investigation. At the start of the 2017 season, the Houston Astros devised a system,

whereby players or team personnel would watch live footage of the game, and then they would

be able to inform the coaches through Apple watches or the players on the field through signs

(Manfred, 2020, 1-2). However, the Houston Astros players believed this method was

ineffective. The commissioner's report states that the method changed about two months into the

season. The new method was a coordination between players, low-level front office employees,

and Alex Cora, who was the bench coach of the Houston Astros. An individual (either a player

or baseball operations employee) would watch the game in the dugout and would determine what

pitch the pitcher was going to throw (Manfred, 2020, 2). After interpreting the catcher's sign, the

individual would bang a trash can depending on the type of pitch (Manfred, 2020, 2). Often, a

bang would mean that a non-fastball or "offspeed" pitch would be thrown. In the commissioner's

report, Rob Manfred states that he was not capable of determining whether or not the system was

effective for hitters and the outcomes of at-bats (Manfred, 2020, 5). Additionally, the report

states that some players believed the method was ineffective and a "distraction."

However, Rob Manfred stated that this use of technology was not accepted under MLB's rules. Under the rules and constitution that govern MLB, Commissioner Rob Manfred financially punished the Houston Astros organization as severely as possible. "The Club will pay to my office a fine of $5 million, which is the highest allowable fine under the Major League Constitution" (Manfred, 2020, 8). Additionally, the Astros lost their first and second round draft picks for the 2020 and 2021 drafts. General Manager Jeff Lunhow and Manager AJ Hinch were suspended for one year. No players were penalized or mentioned in the commissioner's report (except Carlos Beltran who has since retired and was said to have a major role in changing the method).

II. The Structure and Economic Model of Baseball in the 20th century

In this section, the economic model of baseball in the 20th century is explained. I do not take credit for developing this model. The model is explained in Miceli (2019). It is important to understand the differences between baseball in the 20th century and the 21st century in order to explain the harm of the cheating by the Houston Astros. The most important difference is that teams have significantly developed a front office that conducts analysis using technology in the 21st century. Prior to explaining the structure and economic model of baseball in the 20th century, I discuss the similarities between baseball in the 20th and 21st century that are pertinent to this paper.

II.I Similarities Between Baseball in the 20th and 21st Century

Regardless of the century, baseball has always been a sport that involves interdependence between teams and competitors. Any sport requires some level of interdependence between teams or competitors in order for the sport to exist. In MLB, teams cooperate to set a schedule of

games and agree on rules. The cooperation that exists between teams and competitors allows for games or competitions to occur. A pitcher throwing the pitch to the batter is the essential interdependence that allows a baseball game to occur. The performance of a baseball team was rooted in the ability of players on a team to cooperate with one another. The talent of the defense on a team was necessary to prevent runs and the talent of the offense on a team was necessary to score runs.

In baseball, there is an interdependence between the pitcher, catcher, and coaches regarding communication and choosing which pitches are thrown. Often, a coach on the bench signals a sign to the catcher about what pitch should be thrown. The catcher then communicates the recommended pitch to the pitcher. The pitcher then communicates with a head nod indicating "yes" to that pitch, or a head shake indicating "no" to that pitch. There are three reasons for this method of communication: (1) coaches are able to control an aspect of the game, (2) catchers, coaches, and pitchers have the most information about the weaknesses of hitters on the opposing team, and (3) is a safety mechanism for the catcher to know what pitch the pitcher would throw. This method of communication is effective in preventing the other team from knowing what pitch will be thrown, except when the offensive team has a player on second base. When a player is on second base, they are able to see the sign that the catcher indicates to the pitcher, and they are able to inform the hitter what pitch will be thrown. The hitter can then use this information to his benefit to know how to swing at the pitch.

The method of communication that the defense uses illustrates one of the most essential parts of baseball: asymmetric information. Typically, markets need symmetric information in order for the market to function properly. Baseball deviates from the need for symmetric

information because baseball is a non-market activity and it is essential that the pitcher knows

the pitch they should throw and the batter does not know what pitch will be thrown. If the hitter

knew which would be thrown, then they would have a clear advantage and be able to use that

information to get on base. Baseball teams should not cooperate and allow symmetric

information because the outcome of the game would be "fixed" and no longer uncertain. The

utility of the fans is maximized when a game is uncertain. Fans are willing to pay for an

uncertain game because the games are competitive and not "rigged". Asymmetric information

causes fans to be most engaged in watching a baseball game and be willing to pay to attend the

games. MLB and teams are rational to ensure that asymmetric information is an integral part of

games in order to attract fans to watch.

A valid counter-argument is that there have been pitchers who had a "signature pitch"

that they always threw, and the hitter was aware and still unable to get on base. Phil Niekro

threw a knuckleball, Gaylord Perry threw a spitball, and Mariano Rivera threw a cutter, and they

were dominant pitchers. However, not every pitcher is dominant. As a general principle, the

hitter should not know what pitch the pitcher will throw. This principle helps better guarantee

that the outcome of an at-bat is uncertain.

II. The Structure and Economic Model of Baseball in the 20th Century

In the 20th century, baseball teams were built to either maximize profit, maximize wins,

or maximize a mix of profit and wins. Baseball teams were able to maximize profit and/or wins

on the basis of player's talent. Therefore, teams with the most talent would likely have the most

fans and wins. This assertion might be simplistic, but it is valid. In 1927, the New York Yankees

were the most talented team, and the team included seven future hall of famers and had the

highest winning percentage in baseball and won the World Series.

The economic model for baseball in the 20th century defines x as talent, WP as winning

percentage, and winning percentage as a function of talent. The talent was also paid a wage, that

is defined as w. On the business side of sports, total revenue was a function of talent. The more

talent that a team had, the higher the attendance. In the 1927 season, the New York Yankees had

the highest attendance of any team (Baseball Reference, n.d.). Therefore, the function for a win

maximizing team is as follows:

$TR(WP(x))-wx$

Baseball teams deal with a budget constraint, so the function more realistically would be:

$TR(WP(x))-wx \geq 0$

While it is nice to think that every owner and team seeks to maximize winning percentage, that is

not realistic. There were likely owners who owned a baseball team for the purpose of earning

money. These baseball teams would seek to maximize profit and would have the typical profit

function of a firm:

$\pi=P(Q)Q-C(Q)$

Q=the quantity of goods sold (tickets)

P(Q)=the price of the ticket

C(Q)=the labor, material, and capital costs associated with the baseball team

In order to make the model more realistic, teams were likely a combination of

win-maximizers and profit-maximizers. In 1927, the New York Yankees likely maximized the

number of wins based on talent, but also maximized profit. The equation for a team that maximizes wins and profit is as follows:

$$\pi = TR(Q, WP(x)) - C(Q) - wx$$

It is important to note the specialization of labor structure of a MLB team for a majority of the 20th century. The front office labor in baseball was distinctly focused on the business-side of baseball. The front office would hire and trade players, determine business strategies to earn money, and work with other teams to create a schedule among other office duties. The players and coaches were distinctly focused on winning baseball games. There was a clear separation between the duties and responsibilities of the players and the front office (Sometimes the manager of the team was also the general manager of the team). The idea that a person in the front office would interact and give advice to a player on how to hit a baseball was comedic. In an episode of "Seinfeld", George Costanza gives advice to New York Yankees players Derek Jeter and Bernie Williams about how to hit a baseball. The joke had a hidden truth: the people in the front office were intelligent on the business-side, but the idea that they could somehow help the players on the field win baseball games was unheard of and laughable.

III. The Structure and Model of Baseball in the 21st Century

The rules that governed a game of baseball in the 21st century were not extremely different from the rules that governed the game of baseball for the second half of the 20th century. The largest distinction between the 21st century and the 20th century was the use of technology in the front office to help teams win. "Moneyball" ushered in an era of baseball, whereby teams would hire front office staff to analyze data and use technology to improve the team. The Oakland Athletics front office staff were doing their jobs to sign players, which had

always been the role of the front office within the specialization of labor for a baseball team.

Technology only allowed the front office to do their jobs more rationally, productively, and

efficiently.

In MLB in the 21st century, it is common knowledge that all teams have a front office

staff that analyzes the performance of players. With technology, front offices attempt to break

baseball down into a game of patterns. For example, a front office could analyze the strike zone

for a hitter, and be able to determine the locations of pitches that hitters are least likely to make

contact. For the purposes of this example, the hitter is New York Yankees hitter Aaron Judge and

the opposing team is the Boston Red Sox. Figure 2 depicts the strike zone for Aaron Judge, and

various statistics about his performance within each part of the strike zone. The Boston Red Sox

front office would inform the pitchers, coaches, and catchers that Aaron Judge is most likely to

whiff or strikeout when a pitch is thrown inside, and is most likely to make contact when the
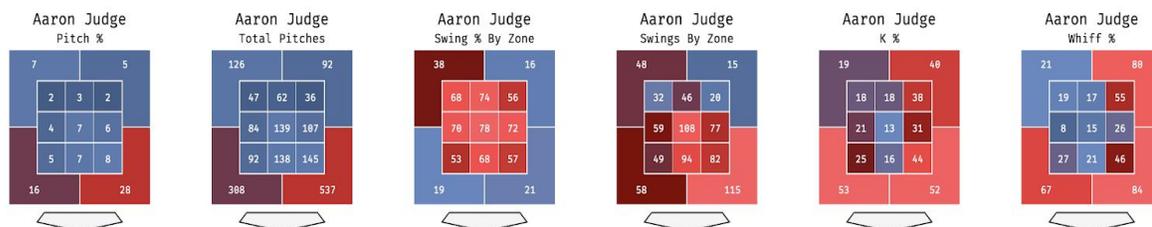
pitch is thrown high and outside.

Figure 2: Aaron Judge Strike Zone Source: (Baseball Savant, n.d.)

Likewise, the New York Yankees front office could use this information to inform Aaron Judge

that he receives a large number of pitches low and inside, and he also is most likely to strike out

and whiff when a pitch is thrown inside. As a result, Aaron Judge would be able to practice

hitting pitches in these areas in order to improve his performance. Front offices have been able to

determine the exit velocity, launch angle, and locations of the pitches that players hit. Similarly,

front office staff have been able to determine for pitchers what their best pitches are, locations of pitches, and other important information.

The most important development of the structure of a baseball team in the 21st century is that there is now an interdependence between the information that the front office is able to acquire, and the performance of players on the field. Every baseball team has a front office with a analytics department that is composed of statisticians, economists, computer programmers, and physicists who seek to acquire this information. At this time, it is nearly impossible to determine the exact impact that an analytics department has on the performance of players because of private information that only the teams are able to access. It can be assumed that the benefits of an analytics department for a team are greater than the costs of the department, and therefore justifies the employment of these individuals.

In baseball, there are still win-maximizing teams, profit-maximizing teams, and a combination of win-maximizing and profit-maximizing teams. Due to the importance of technology in the game of baseball, technology must be added to the economic model of baseball. Teams no longer depend on just talent to win baseball games, but also depend on the benefits that technology provides for the players. Winning percentage has become a function of talent and technology, and total revenue is a function of winning percentage. Talent is still paid a fixed wage, and there is a fixed cost associated with technology (labor, cost of technology). The equation for total revenue of a win-maximizing and profit-maximizing team is as follows:

$TR(WP(x, t)) - wx - st$

s=cost associated with technology

t=level of technology

The profit equation for a win-maximizing and profit-maximizing team is as follows:

$$\pi = TR(Q, WP(x,t)) - C(Q) - wx - st$$

The technology of baseball teams that I have written about so far is considered the *legal technology* that baseball teams are allowed to use. For the purposes of this paper, *Legal technology* is defined as the technology that teams use off the field to analyze performance of players. Information that is acquired through *legal technology* can be used to inform the players and improve the performance of the players. In MLB there is also *illegal technology*. For the purposes of this paper, *on-field illegal technology* is defined as technology that is used on the field during a game and *off-field illegal technology* is defined as technology that is used to acquire information from the technology of other teams. *On-field illegal technology* tampers with the competitive nature of a baseball game that is based on human talent and capabilities and is considered illegal on the league level. *Off-field illegal technology* is a much more serious offense and is considered illegal on the league level and "society level" (involves law enforcement, such as the FBI).

MLB has to make policy decisions about which actions are legal or acceptable and which actions are illegal or unacceptable. Steroids, betting on games, and throwing spitballs are actions that MLB has declared to be illegal under the league's rules. However, a runner on second stealing signs, "Moneyball" technology, and defense using hidden ball tricks to tag runners out are all considered legal and acceptable actions. Under MLB's current rules, *on-field illegal technology* and *off-field illegal technology* are not allowed and punished. However, MLB has not been capable of deterring teams from using illegal technology. MLB must determine rules about

what types of sign stealing are legal and what types are illegal. Sign stealing has always been a gray area of baseball's rules, but the use of illegal technology has only revealed the problems that sign stealing can cause.

There is a history of teams in the 2010s using illegal technology as explained in the background section. The actions of the Houston Astros in the 2017 season would be considered use of *on-field illegal technology* and the actions of the St. Louis Cardinals would be considered use of *off-field illegal technology.*

The equations for the baseball teams in the 21st century need to be modified to include the existence of illegal technology. The total revenue function for a win-maximizing team is as follows:

$TR(WP(x, t, b))-wx-st-p(b)f$

b=illegal technology

$p(b)$=probability that illegal technology (b) results in detection

f=fine that would be imposed on team for using illegal technology

The profit function for a win-maximizing and profit-maximizing team is as follows:

$TR(Q, WP(x, t, b))-C(Q)Q-wx-st-p(b)f$

It is important to note that teams can choose to have b be equal to 0, meaning that they do not use any illegal technology. However, teams do use illegal technology and there are substantial fines that are associated with the technology because of the harm created by that technology.

IV. Economics of Penalties in MLB

The purpose of this section is to describe the economics of penalties in MLB. This section is set up in two subsections. The first subsection describes how penalties impact the behavior of teams and players. The second subsection describes how violations are enforced.

A. How Penalties Impact Behavior of Players and Teams

Players and teams have the choice to play a game of baseball the "right way" (i.e., no rules violations, such as none of the following: gambling, PEDs, illegal technology, etc) or the "wrong way" (i.e., breaking rules such as the following:, gambling, PEDs, illegal technology, etc). MLB has rules in place to deter the behavior of playing baseball the "wrong way". Based on the assumption that teams and players act rationally, players and teams will make decisions if the benefits are greater than the costs. Players and teams will choose to violate rules if the benefits of the violation are greater than the costs of the violation. A player or team will not make a decision, whereby the costs of the violation are greater than the benefits of the violation.

Bounded rationality is used for choices about whether or not to commit a violation. Players and teams do not perfectly know the exact harm, benefit, or violation that will be imposed. As Jolls, Sunstein, and Thaler (2004) observed, people will make judgments that are based on recent events and will use bounded rationality to determine whether or not they should commit a crime when there is uncertainty about their chances of being caught. Players and teams are not perfect calculators, but they are capable of making judgements about playing baseball the "right way" or the "wrong way". The economic model below is from chapter 7 of Miceli (2019). An assumption of the model is that the economic agents are rational. However, I argue that bounded rationality can be used for this model, but the calculations become more imprecise.

For this model, x is the action that a team or player uses in order to win, and the action could be considered a violation. p(x) is the probability that x results in a team winning a game or receiving an advantage over the other team. V is the reward for a team or player if they win the game or receive a bonus or award (such as using PEDs to achieve a salary bonus or win Most Valuable Player). r(x) is the probability that x results in a violation. r(x) is less than 1, meaning that no action is guaranteed to be a violation. q is the probability that the violation will be detected. No violation will be perfectly detected. As experienced with PEDs, MLB did not have a perfect detection system for players to be caught using the PEDs. Many players have been rumored to use PEDs, but MLB did not detect them using PEDs. f is the sanction or fine that is imposed on a player for being detected and caught. Therefore, a team will violate the rule when:

p(x)V>r(x)qf

Therefore, if p(x)V>r(x)qf, then the player or team will violate the rule because the benefits of victory are greater than the costs of using that action. The penalty does not effectively deter the player(s) or team from using that action.

A team will not violate the rule when:

p(x)V<r(x)qf

Therefore, if p(x)V<r(x)qf, then the player or team will not violate the rule because the benefits of victory are less than the costs of using that action. The player or team is effectively deterred from using that action.

B. How MLB Enforces Rule Violations

MLB has several methods to enforce rules violations: fines, suspensions, loss of draft picks, and banishment from the game of baseball. MLB has significant discretion in enforcement

and penalties. Both MLB and teams become uncertain about the level of a penalty when the violation has never occurred in baseball history. Penalties are known to be adapted and modified to become more strict. In the steroids era, MLB had substantial problems with players using PEDs despite enforcement. In response, MLB created stricter punishments for when players use steroids. It is important to note that players can be punished by MLB, and be punished by the criminal justice system. Under the constitution for MLB, a fine cannot exceed $5 million. When committing a violation, baseball teams and players must account for $5 million being the upper limit on the violation and $0 being the lowest limit on the violation. A fine can also be combined with a loss of draft picks, suspensions, and/or a ban from the game of baseball.

Figure 3 displays three isoquants and the relationship between detection and the different levels of fines and sanctions (s). Figure 3 is strictly concerned with actions that relate to competitive balance. Harm (h) is not quantifiable, but it is a qualitative value that can be separated into an action being low harm, high harm, or severe harm. Low harm would be considered actions that cause some damage to the game of baseball, but the actions are not significant enough to jeopardize competitive balance in the long term. High harm would be considered actions that cause considerable damage to the game of baseball and could jeopardize competitive balance. Severe harm would be considered actions that cause considerable damage to the game of baseball, but also result in the criminal justice system being involved. Figure 3 lists examples of actions that would be considered low, high, and severe harm, and the respective levels of detection and sanction associated with each action. Figure 3 is a modified version of the isoquants that appear in Miceli (2020). Figure 3:
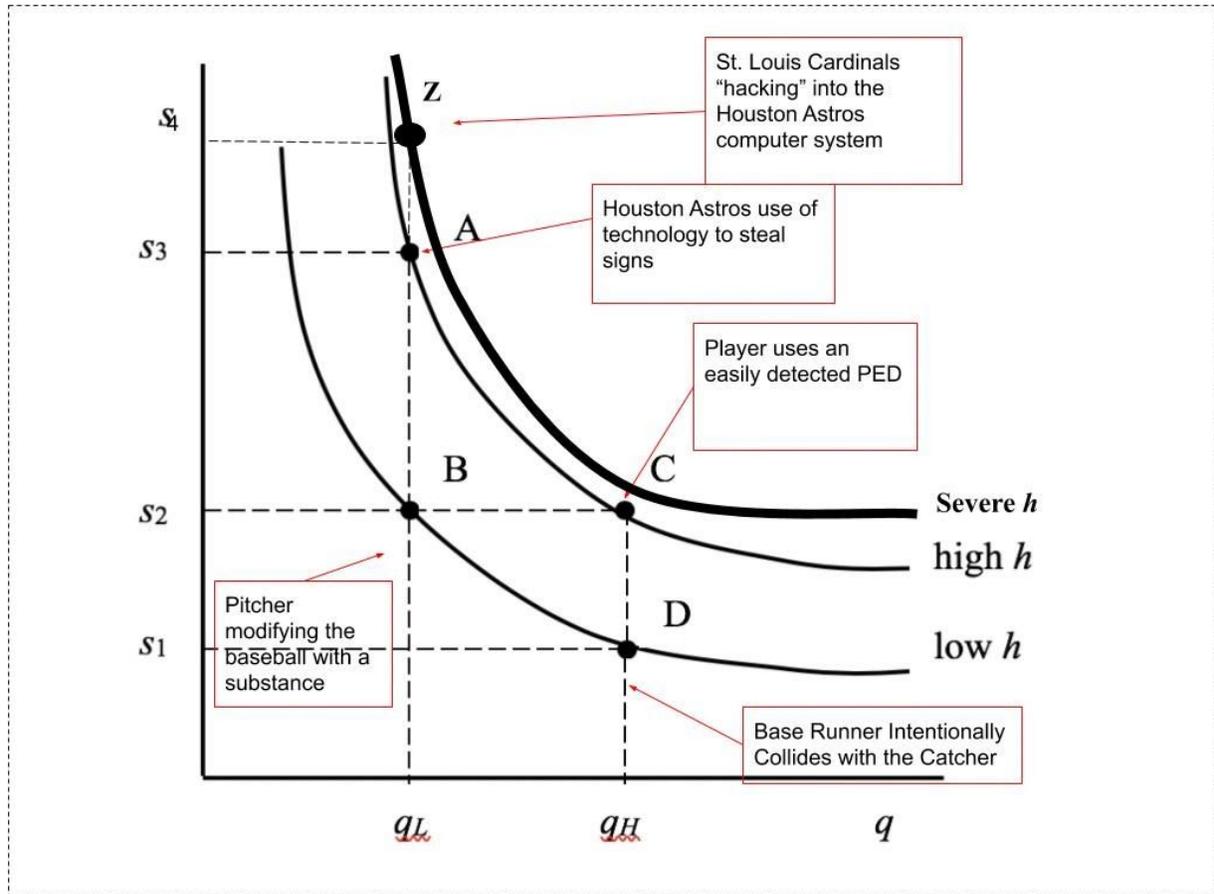
V. Houston Astros Use of Illegal Technology in the 2017 Season

The Houston Astros in the 2017 season used what is considered *on-field illegal technology* in order to gain an advantage over the team's opponents. The method that the Houston Astros used to steal the catcher's signs was explained in the background section. Based on the discussion in section IV, the Houston Astros were rational in their use of *on-field illegal technology*. The objective of the Houston Astros and every baseball team was to win the World Series. However, the preferences of the Houston Astros organization were likely different from every other team for that season. The ranked preferences of the Houston Astros in the 2017 season were likely as follows:

(1) win games (ignoring how baseball ought to be played)

(2) win games based on talent and legal technology

(3) lose games

Other baseball teams in 2017 likely had the following preferences:

(1) Win games based on talent and legal technology

(2) Lose games

(3) Win Games (ignoring how baseball ought to be played)

In the Houston Astros' pursuit of its objective to win the World Series, the team found the best, least cost way to win games and the World Series was through devising a strategy using *illegal technology*. The Houston Astros understood the punishments that MLB could use to punish them if the illegal technology was detected: a maximum fine of $5 million, suspensions, loss of draft picks, and permanent ban from baseball. The decision-making process behind the Houston Astros decision to use the *illegal technology* is likely more complicated than simply calling the action "rational." The Houston Astros used bounded rationality in its decision-making process.

The Houston Astros considered V to be the benefits of winning the World Series and s to be the fine for using *illegal technology* that could be less than or equal to $5 million plus additional non-financial penalties. The Houston Astros were also aware that the probability that the action would result in a violation $r(x)$ was low because only the Houston Astros players knew about the system, and opposing teams could not easily prove the Astros were stealing signs. The use of the technology was certainly a violation, but the probability of detection was very low. The only reason that the Houston Astros were caught was because Mike Fiers was a whistleblower who had been traded to another team. However, the remaining variables were

completely unknown. The Houston Astros could not have perfectly known the outcomes of

games and the probability that they would win the World Series using illegal *technology*. The

Houston Astros understood that the *illegal technology* would give them a significant advantage

over the opposing teams. It is extremely difficult to forecast a baseball season that has not yet

occurred, much less exactly predict the benefits that a technology would give the team.

The Houston Astros also did not fully know what the non-financial penalties would be if

detected. In the cost-benefit analysis, the Houston Astros must have projected the fine to be $5

million. As stated in the introduction, $5 million is equivalent to the salary for the average player

in MLB. If the Astros knew there was a player that they could sign for $5 million and he would

give the team a significant advantage, then the team would have signed that player. While they

understood the fine could be $5 million, the team did not know who would be suspended, if they

would lose draft picks or if any player or personnel would be banned from the game of baseball.

The Houston Astros were also likely to be extremely uncertain about the probability of detection.

The players and personnel did not know if fans or opposing players would be able to hear the

bangs.

The reason that the Houston Astros were largely uncertain about the punishment and

probability of detection was because no team had ever used *illegal technology* to steal the

opposing team's signs and were caught by MLB. The only other event in MLB history that was

similar to the Houston Astros use of *off-field illegal technology* was the St. Louis Cardinals

hacking and entering into the *legal technology* of the Houston Astros. The St. Louis Cardinals

were caught and the team was fined $2.5 million, lost draft picks, and the employee leading the

initiative was sentenced to prison for a felony. The benefits of hacking into the Houston Astros

computer system were less than the costs of doing so for the Cardinals organization. The

decision-making of the St. Louis Cardinals personnel was impacted because there were no

similar events in baseball history. The personnel likely believed they would receive important

information about players, and would not be detected. However, they were. As a result, the

Houston Astros understood there was a possible chance they would be detected. The cost of

being sent to prison was likely considered too great of a cost to justify the use of illegal

technology similar to the Cardinals. Instead, the Houston Astros determined a strategy to use

illegal technology, so that no team personnel would be sent to prison.

The plan was simple: steal the signs that the opposing teams reveal to the cameras in

center-field. The unwritten rule of baseball that if a team had a runner on second base was

extended using technology. The Houston Astros understood that they would be penalized by

MLB for using *on-field illegal technology*, but they would not be penalized by the United States

criminal justice system.

Currently, the debate over the Houston Astros cheating scandal is based on the

assumption that the team gained an advantage from its use of illegal technology. However, there

is no available statistical analysis or data that proves this statement. Instead, there is data that can

be used to support the statement that Houston Astros were outliers in regular season

performance, and the team's use of illegal technology correlated and likely contributed to the

team's performance. Table 1 displays the regular-season offensive rankings for a team in the

year in which they won the World Series. For example, in the 2019 season, the Washington

Nationals ranked 27th in strikeouts, 6th in batting average, 2nd in On-base percentage, 7th in

slugging percentage, and 6th in on base plus slugging percentage. In the 2017 season, the

Houston Astros ranked 30th in strikeouts, 1st in batting average, 1st in on-base percentage, 1st in

slugging percentage, and 1st in on base plus slugging percentage. It is not unusual for the team

that wins the World Series to have exceptional offensive statistics in the regular season as seen

with the other teams in the table. However, the performance of the Houston Astros is clearly the

best out of any team between 2009-2019 in terms of rankings. The team that has a comparable

performance to the 2017 Houston Astros is the 2018 Boston Red Sox (Major League Baseball is

currently pursuing an investigation for the team's alleged use of illegal technology). The

performance of the 2017 Houston Astros is correlated to the team's use of illegal technology.

Every team in these rankings had exceptional offensive talent and used legal technology. The

Astros cheated, which was something different from the rest of these World Series champions,

and that will always be an asterisk on that team.

Table 1: Ranking of Regular-Season Offensive Statistics for World Series Teams

Year	World Series Champion	Number of Strikeouts	Batting Average	On Base Percentage	Slugging Percentage	On Base Plus Slugging Percentage
2019	Washington Nationals	27th	6th	2nd	7th	6th
2018	Boston Red Sox	26th	1st	1st	1st	1st
2017	Houston Astros	30th	1st	1st	1st	1st
2016	Chicago Cubs	9th	14th	2nd	10th	3rd
2015	Kansas City Royals	30th	3rd	11th	11th	10th
2014	San Francisco Giants	17th	10th	18th	13th	14th
2013	Boston Red Sox	8th	2nd	1st	1st	1st
2012	San Francisco Giants	26th	5th	8th	18th	14th
2011	St. Louis Cardinals	29th	5th	3rd	6th	5th
2010	San Francisco Giants	19th	15th	19th	13th	17th
2009	New York Yankees	27th	2nd	1st	1st	1st

Source: (ESPN, n.d.)

VI. Illegal Technology and the Prisoner's Dilemma

The use of illegal technology creates a prisoner's dilemma for MLB. As explained

previously, professional sports experienced a prisoner's dilemma with the use of PEDs. In MLB,

PEDs were widely used because of the expected advantages that players would receive from the

drugs. The use of *illegal on-field technology* is likely to become (or already is) a prisoner's

dilemma for MLB. When the incentives of winning a baseball game dramatically increase, the

prisoner's dilemma with the use of illegal technology is only more likely to occur. The

assumptions and math used for this prisoner's dilemma are adapted and modified from "The

Performance-Enhancing Game" by Kjetil K. Haugan (2004). The prisoner's dilemma of PEDs

and the prisoner's dilemma of illegal technology are similar because both involve strategies that

can increase the probability of winning and give a team or player an advantage over the

opponent.

VI.I The Assumptions of the Prisoner's Dilemma for Illegal Technology

The assumptions for the prisoner's dilemma for illegal technology:

1. There are two baseball teams who have players of equal talent and equal legal technology

   capabilities.

2. Each baseball team is capable of choosing between legal and illegal technology as a

   strategy

   a. Illegal technology indicates that the team is using legal technology as well.

3. The illegal technology provides an advantage if a team uses it. If one team uses illegal

   technology and the other team does not use illegal technology, then the team that uses the

   illegal technology will have a higher probability of winning that game.

   a. For the purposes of this prisoner's dilemma, the team that does use the illegal

      technology has an 80% chance of winning, and 20% chance of losing. The team

that does not use the illegal technology has a 20% chance of winning, and 80% chance of losing.

4. If both teams use the illegal technology, then they will be considered equal competitors and have an equal probability of winning. If both teams use the legal technology, then they will be considered equal competitors and have an equal probability of winning.

    a. Both teams have a 50% chance of winning and a 50% chance of losing

5. Both baseball teams must make a choice about whether or not to use illegal technology simultaneously prior to the start of a baseball game. (There are costs to setting up the illegal technology and coordination between players and front office personnel that must occur.)

6. To make the prisoner's dilemma simpler, the two teams will play one baseball game. Imagine that the baseball game is Game 7 of the World Series. This means that the teams have faced off in 6 games previously, and each team has a record of 3 wins and 3 losses against the opponent. If a team wins the game, then they win the World Series Championship, and receive a large financial bonus (in 2017, the bonus was around $30 million). If a team loses the game, then they do not receive a championship, but they do receive a considerably smaller financial bonus (in 2017, the bonus was around $20 million)

7. Each team has the same payoffs that can be obtained:

W= Team wins the game

L= Team loses the game

S= Team is caught for using the illegal technology

P= Probability that team wins

The following payoffs are the utility payoffs and costs associated with winning or losing the

game:

U(W)=utility of winning=30

U(L)=utility of losing=10

U(S)=sanction for using the illegal technology=-5

8. The teams must make the choice about whether or not to use illegal technology based on

   the following expected utility payoffs

   a.) Both Teams Use Legal Technology: EU=.5U(W)+.5U(L)

       a. EU=.5(30)+.5(10)=20

       b. Probability of winning=.5

       c. Probability of losing=.5

B and C.) One team uses illegal technology: EU=.8U(W)+.2U(W)-S

    EU=.8(30)+.2(10)-5=21

    Probability of winning=.8

    Probability of losing=.2

One team uses legal technology: EU=.8U(L)+.2U(W)

    EU=.8(10)+.2(30)=14

    Probability of losing=.8

    Probability of winning=.2

d.) Both Teams Use Illegal Technology: EU=.5(W)+.5U(L)-S

    EU=.5(30)+.5(10)-5=14

Probability of winning=.5

Probability of losing=.5

9. The teams have homogeneous preferences and the payoffs are ranked in the following

   way:

● One team uses illegal technology, and the other team does not use illegal technology.

● Both teams use legal technology

● Both teams use illegal technology

● The team loses

10. The team who wins the baseball game will not lose the rewards of winning (bonuses,

    championship title) if the team is caught for use of illegal technology after the game has

    occurred. (The Astros have kept the rewards of winning the 2017 World Series)

11. If a team uses the illegal technology, then the team will be detected and caught with

    certainty.

12. Both teams have the catcher signal pitches to the pitcher. This assumption allows a team

    to potentially use the illegal technology that can decipher the signs.

13. Each team is aware of the rules of MLB and the assumptions.

VI.II Prisoner's Dilemma

Figure 4 displays a matrix with payoffs based off of the above equations for when a team has to

choose between legal technology and illegal technology. Figure 4:

Team 2

Team 1

	Legal Technology	Illegal Technology
Legal Technology	Teams have an equal probability of winning. Outcome is uncertain. EU=.5U(W)+.5U(L)	Team 1 will lose. Team 2 will win. Team 1: EU=.8U(L)+.2U(W) Team 2:EU=.8U(W)+.2U(L)-S
Illegal Technology	Team 1 will win. Team 2 will lose Team 1: EU=.8U(W)+.2U(L)-S Team 2: EU=.8U(L)+.2U(W)	Teams have an equal probability of winning. Outcome is uncertain, but each team will pay a penalty. EU=.5(W)+.5U(L)-S

Figure 5 displays a matrix with numbers as payoffs that reflect the financial payoffs of winning

the World Series. Figure 5:

Team 2

Team 1

	Legal Technology	Illegal Technology
Legal Technology	Team 1: 20 Team 2: 20 (Each team has a 50/50 chance of earning either 30 or 10.)	Team 1: 14 Team 2: 21 (Team 1 will lose and Team 2 will win, but pay a cost of $5 because of illegal technology)
Illegal Technology	Team 1: 21 Team 2: 14 (Team 2 will lose and Team 1 will win, but pay a cost of $5 because of illegal technology)	Team 1: 15 Team 2: 15 (Each team has a 50/50 chance of winning either 25 or 5.)

This matrix displays a prisoner's dilemma because both teams have a dominant strategy to use illegal technology and the equilibrium is (Illegal Technology, Illegal Technology). When both teams use the illegal technology, they accept a mutually bad outcome that has the lowest payoffs. (Illegal Technology, Illegal Technology) is a Nash Equilibrium because both teams use a dominant strategy, the equilibrium is mutually bad, and is sub-optimal. The optimal equilibrium is (Legal Technology, Legal Technology), but this will not be the outcome because of the existence of illegal technology. Each team understands that illegal technology is the dominant strategy. Each team prefers the certainty of winning and using illegal technology. If the teams are rational, then they will choose the dominant strategy because they know the other team is likely to use illegal technology. Even if the opposing team does not use illegal technology, then the team will still benefit from the use of illegal technology because they will win. Each team has the perverse incentive of using illegal technology because the cost of the penalty is such that winning still has more value than losing.

In order to make this prisoner's dilemma more realistic, two assumptions must change and the teams have heterogeneous preferences. Team 1 ranks their preferences in the following way:

(1) win games (ignoring how baseball ought to be played)

(2) win games based on talent and legal technology

(3) lose games

Team 2 ranks their preferences in the following way:

(1) Win games based on talent and legal technology

(2) Lose games

(3) Win Games (ignoring how baseball ought to be played)

As a result, there is one team that plays baseball the "right way" and the other team plays

baseball the "wrong way". Team 1 would be considered pro-cheating and Team 2 would be

considered anti-cheating. Team 2 is so against cheating, such that any benefits they gained from

cheating would be cancelled by the team's displeasure, and the team's payoff would become the

cost of cheating. Figure 6 displays the matrix for this scenario. The dominant strategy for team 1

is to use legal technology and the dominant strategy for team 2 is to use illegal technology. The

suboptimal equilibrium for this matrix is (Legal Technology, Illegal Technology). In this

equilibrium, team 1 cheats and receives a benefit from cheating, while team 2 does not cheat.

Team 1 has only a 20% chance of winning because they used legal technology to play baseball.

However, Team 2 has a 80% chance of winning because they used illegal technology to play

baseball. The optimal equilibrium for this matrix is still (legal technology, legal technology).

Figure 6:

<center>Team 2</center>

Team 1

	Legal Technology	Illegal Technology
Legal Technology	Team 1: 20 Team 2: 20 (Each team has a 50/50 chance of earning either 30 or 10.)	Team 1: 14 Team 2: 21 (Team 1 would likely lose and Team 2 would likely win, but pay a cost of $5 because of illegal technology)
Illegal Technology	Team 1: -5 Team 2: 14 (Team 2 would likely lose and Team 1 would likely win, but pay a cost of $5 because of illegal technology)	Team 1: -5 Team 2: 15 (Each team has a 50/50 chance of winning, but Team 1 would receive -5, and Team 2 would receive 15)

The equilibrium explained in the previous paragraph and figure has real world implications in MLB. In the 2017 World Series, the Houston Astros played the Los Angeles Dodgers. At this time, it cannot be said that the Houston Astros used illegal technology in the World Series, but they did use the illegal technology in many regular-season and postseason games that season. Players on the Los Angeles Dodgers believed that the Houston Astros did use illegal technology during the World Series. The Los Angeles Dodgers players have also voiced their unhappiness about the Astros actions. The Los Angeles Dodgers likely did not establish their own illegal technology scheme because of their moral beliefs about how baseball ought to be played. If that was the case, then figure 6 would have predicted the outcome. With the Houston Astros using illegal technology, the game was no longer based on talent and legal technology, but was based on the use of illegal technology and technology. Out of every baseball game in the 2017 season, game 7 of the World Series had the largest incentives for the winning team.

This prisoner's dilemma can be extended to every regular-season game. It is extremely difficult for a team to reach the postseason and the World Series. The Houston Astros were willing to use illegal technology for multiple games in the season in order to reach the postseason. In the 2017 season, other teams were uncertain about whether or not the Astros were using illegal technology. Other teams in the MLB had to make a choice about whether or not they should use illegal technology, and many chose not to because they were uncertain about the strategies of their opponents. It was not until after the 2019 season that it was formally determined that the Houston Astros had used illegal technology. After the 2018 season, the

Boston Red Sox have been accused of developing an *illegal on-field technology* method to communicate. In future seasons, the likelihood that other teams will adopt illegal technology schemes is only more likely because there is knowledge of two teams choosing that strategy. The value of winning the World Series is so great, and the deterrents are so weak, such that teams are willing to use illegal technology in order to improve their chances.

Cooperation is often stated to be the solution to overcoming the prisoner's dilemma. Baseball teams currently attempt to cooperate through MLB. In order for the teams to be able to escape the prisoner's dilemma, then teams must accept policy changes. MLB did not intend to make the teams be part of a prisoner's dilemma, but that is the effect of capping penalties. One solution is for MLB to remove the limit on penalties, and allow penalties to be greater than $5,000,000. MLB could then effectively match the penalty to the behavior. MLB must fine teams in such a way that the fine is able to effectively deter behavior that is harmful to competitive balance and uncertainty of outcome. For example, the fine for using illegal technology could drastically increase above $5,000,000 for game 7 of the World Series when the payoffs are the highest. The fine or penalty could be increased such that the value of losing is greater than the value of winning if a team were to use illegal technology.

However, this may not be an effective deterrent because individual players might be able to use illegal technology that the team does not know about. If this is the case, then MLB may struggle to deter these players because the illegal technology could improve the performance of players that is then rewarded on the labor market. Additionally, teams may not want to accept this policy change because there is uncertainty about how that fine might impact teams in the

future. The uncertainty causes teams to reject a policy that would otherwise lead to a pareto optimum equilibrium.

VII. Irrationality, Status Quo Bias, Nudge, and Changing Baseball

The defense of teams has become irrational due to the team's knowledge that other teams were likely stealing signs using illegal technology, but the defense did not change its behavior. The defense has an objective to prevent the offense of the other team from scoring runs. The offense of a baseball team has an objective to score runs. The defense will logically use various strategies and take actions that prevent the offense from scoring runs. If the offense knows what pitches will be thrown, then that is harmful to the objective of the defense. As discussed previously, asymmetric information is important for the game of baseball because only the defense is supposed to know what pitch will be thrown. As a result, the preferences of the defense are as follows: (1) indicate signs to the pitcher without the opposing team knowing or (2) indicate signs to the pitcher with the opposing team knowing.

The defense of baseball teams are acting irrationally because they are not choosing the preference that they prefer the most. The existence of illegal technology has allowed the offense to decipher the catcher's signs. The defense on every team is aware of the benefits and use of illegal technology by the opposing team. However, baseball teams have not changed the strategy of how pitches are called by the catcher. Baseball teams have created complicated signs to signal to the pitcher, but the technology is likely able to decipher the signs. In the 2019 World Series, the Washington Nationals suspected that the Houston Astros were stealing signs, so they responded by creating complicated signs to beat the technology. However, baseball teams are limited by the human capabilities of the defense. The signs that catchers use can be broken down

into patterns that are analyzed by the technology. Regardless of how complicated the signs are, the technology has a high likelihood of being able to determine what pitches will be thrown.

An explanation for why the defense of baseball teams and the MLB have not avidly pursued a change in how pitches are called is because of the status quo bias. Catchers signaling to the pitcher is considered the default and most time-efficient option for defenses to use. Baseball has always been played in this way, and there has never been a reason to alter this method unless there was a runner on second base. Innovations and the use of illegal technology have allowed the offense to manipulate the default option for the offense's benefit. MLB and baseball teams understand this manipulation is occurring, but the teams are experiencing inertia, in which the organizations are unwilling to change because of the traditions of the sport. MLB and teams understand that baseball has always been played this way, so it must not change from this "status quo". The unwillingness to change how pitches are called has further forced teams to accept a sub-optimal position in the MLB. If the defense does not change how they call pitches, then offenses will continue to develop technology or methods to steal signs.

Richard Thaler and Cass Sunstein argued that people could be "nudged" away from the default option, which would otherwise be an irrational choice, to a better option, which would be considered rational. Could MLB, acting as a choice architect, attempt to nudge teams to act rationally and not use illegal technology? The answer is yes, but there is uncertainty about whether or not the nudges would actually be able to change behavior of teams and players. The discussion for the remainder of this section is speculative and the exact impacts of the changes are unknown.

MLB could adopt aspects of the philosophy and approaches of libertarian paternalism. MLB is already a mix of libertarianism and paternalism. The fines and suspensions are punishments that the MLB is capable of making because of its paternalistic structure. The labor market in MLB and the choices that teams make regarding players is fully at the discretion of the team and part of the libertarian structure. So how would libertarian paternalism apply to baseball? The answer is that MLB can encourage the defense to use electronic equipment when calling pitches, but not mandate that method. I am doubtful of the ability of defenses to create complicated signs that can outsmart the illegal technology. If the pitcher, catcher, and coach could communicate through headsets, then they would be able to choose which pitch to throw and the offense would not be aware of the pitch. Headsets would remove the ability of the offense to use illegal technology that can decipher signs. MLB has been resistant to use headsets because of the status quo bias that was described previously. The belief that baseball should be played as it always has been, and introducing headsets would ruin baseball is very strong. However, the use of illegal technology is a much larger threat to the competitive nature of baseball. Headsets would likely move baseball towards a state of competitive balance because each team could adopt this "legal technology" that would prevent any chance that the other team could steal signs. Joe Girardi and others have advocated for the use of headsets in baseball.

In order to encourage baseball teams to not use illegal technology, Major League Baseball should improve the league's whistleblower system. Pitcher Mike Fiers was the whistleblower who informed the media about the actions of the Houston Astros in 2017. Mike Fiers has been criticized in sports media and he has also received death threats for being a whistleblower. Arguably, death threats are enough of a deterrent to prevent people from speaking

the truth. In future seasons, when a player discovers egregious behavior on a team, should that player be a whistleblower after the treatment of Mike Fiers? This is a question that MLB needs to grapple with in future feasons. MLB should improve the whistleblower system to protect the identity of the individual and prevent the whistleblower from being forced to go public. If a player is able to receive protection of their identity, then they are more likely to inform the MLB when a team is behaving egregiously. By protecting the whistleblower, MLB is "nudging" teams to not cheat. MLB needs to expect teams to make errors, in the sense that teams will cheat in order to win. MLB needs to institute a mechanism that can effectively catch these "errors" before they might happen. The whistleblower would be equivalent to the light on a car that informs the driver they need to fill their gas tank. Teams would then assume that at least one of its players would be a whistleblower. If teams understood there was a higher probability that they would be caught for their actions in the immediate future, then they would not cheat or use illegal technology. The idea that at least one of the players could be a whistleblower could "nudge" teams to choose a Pareto optimal strategy to attempt to win solely on the basis of talent and legal technology.

MLB teams need more "feedback" about the extent of Houston Astros sign-stealing methods and the advantages and benefits that the team received. More "feedback" could lead to the defense of teams improving their methods of signaling pitches or changing to technology. In the Commissioner's Report, the claim that the Astros devised a system to steal signs was verified. However, the report left several questions unanswered. In how many games did the Astros steal signs? In which games did the stealing signs lead to more runs, home runs, and hits? Was stealing signs even effective? Currently, the publicly available data on the extent of the

Houston Astros sign-stealing methods is incomplete. A baseball fan created a system that

detected when the Astros banged before a pitch in 60 of the team's home games. The results

were that the Astros used the system consistently throughout the season. However, there is no

data for the remaining 102 games. MLB is capable of discovering the extent to which the Astros

stole signs. A more in-depth report regarding the data of Astros sign-stealing would "nudge"

teams to take more precautions in communicating signs. Support for the use of headsets would

likely increase as a measure to protect signs from being stolen. The defense of teams would then

act rationally and choose to find a method to indicate signs to the pitcher without the opposing

team knowing what pitch would be thrown.

Areas for Further Discussion and Challenges

This paper is written on the belief that the Houston Astros gained an advantage from the

use of *illegal on-field technology*. It is unclear whether there was an advantage because there is

incomplete data on the 2017 season. Additionally, the prisoner's dilemma that baseball will

encounter with illegal technology assumes that both teams have an equal probability of winning

without illegal technology. It is exceptionally rare to have two teams that have an equal

probability of winning. This assumption allows the argument to be built that baseball is in a

prisoner's dilemma. The use of this unrealistic assumption does not mean that the use of illegal

technology is not a prisoner's dilemma. Instead, it just makes the scenario more easy to explain.

If there was a competitive imbalance between the teams, then the weaker team would use illegal

technology to be balanced with the better team, and the better team would gain a more

significant advantage over the weaker team. Additionally, the economic models of baseball in

the 20th century and 21st century are difficult to actually study. It is unknown the exact benefits

that a team gains from the use of technology. It is also unknown exactly how to measure talent of a baseball team. Additionally, a psychological analysis of the Houston Astros in the 2017 season would be beneficial to this paper. It is evident that the Astros were overconfident in their ability to be detected. Heuristics likely impacted the decision-making of the Astros.

Conclusion

The analysis of the differences between MLB in the 20th century and 21st century revealed the impact that technology has had on the game of baseball. In the 21st century, front offices use technology in order to obtain information that better informs the players about their strengths and weaknesses, and those of their opponents. Baseball players and the front office staff have become interdependent in order to win baseball games. Within MLB, there is a distinction between legal technology and illegal technology. All baseball teams currently adopt the use of legal technology. However, the use of illegal technology by baseball teams is linked to the existence of a prisoner's dilemma in MLB. Illegal technology is believed to give an advantage to one team over the other. However, if both teams use illegal technology, then the benefits are nullified. There are two potential prisoner's dilemmas in MLB. The first prisoner's dilemma involves both teams having a dominant strategy to use illegal technology. This results in a Nash sub-optimal equilibrium, whereby both teams use illegal technology and they both accept mutually bad outcomes. The second prisoner's dilemma involves one team having a dominant strategy to use illegal technology and one team having a dominant strategy to only use legal technology. In this prisoner's dilemma, a suboptimal equilibrium occurs, whereby the team that uses the illegal technology has a clear benefit and is more likely to win, while the team that uses the legal technology experiences a disadvantage and is less likely to win.

After the actions of the Houston Astros in the 2017 season and the subsequent

investigation and penalties, it can be argued that the current penalties are not an adequate

deterrent for the use of illegal technology. MLB must determine and configure a better system to

discourage the use of illegal technology. This paper provided some policy solutions, such as

improved data on the benefits that the Astros received from the technology, a more protective

whistleblower system, and the use of headsets by the catcher, pitcher, and coach that MLB could

implement. If MLB does not correct the behavior of teams, then competitive balance and the

uncertainty of outcomes for baseball games is in jeopardy.

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Appendix:

Regular-season team offense statistics were found on the website of ESPN.

Here are website links for the seasons of 2009-2019:

2019: http://www.espn.com/mlb/stats/team/_/stat/batting

2018: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2018

2017: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2017

2016: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2016

2015: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2015

2014: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2014

2013: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2013

2012: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2012

2011: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2011

2010: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2010

2009: http://www.espn.com/mlb/stats/team/_/stat/batting/year/2009