

A System Dynamics Examination of the Use of Performance Enhancing Drugs

**John Voyer, Ph.D.
Cade Blackburn
Troy Goddu
Brian Sprague**

School of Business
University of Southern Maine
96 Falmouth St.
Portland, ME 04104-9300

Corresponding author:

John Voyer
207-780-4597

voyer@usm.maine.edu

Abstract

Athletes face tremendous pressure to perform, and, when conventional means prove insufficient for performance improvement, some turn to performance enhancing drugs (PED's). The present paper uses system dynamics to examine one example: the use of anabolic androgenic steroids in Major League Baseball (MLB), which operates in the United States and Canada. The authors provide an explanation of a detailed causal loop diagram of the problem, along with a stock and flow model, based on the Bass Diffusion Model, of part of the problem. They provide a few policy recommendations based on model runs.

Key Words: Performance Enhancing Drugs, System Dynamics, Major League Baseball, Bass Diffusion Model

A System Dynamics Examination of the Use of Performance Enhancing Drugs

Athletes face tremendous pressure to perform, and, when conventional means prove insufficient for performance improvement, some turn to performance enhancing drugs (PED's). The present paper uses system dynamics to examine one example: the use of anabolic androgenic steroids in Major League Baseball (MLB), which operates in the United States and Canada.

Steroids are a controlled substance, and MLB (and other sports) bans them because of the effect they have on the user. Positive effects in the short term include an increase in lean muscle mass, strength, and the ability to train longer and harder. This usually translates into a better athlete. For example, the use of steroids took center stage during the home run race in the late 1990's between Mark McGuire and Sammy Sosa. It was widely believed that both men used steroids to improve hitting performance. Although the race between these two sluggers was exciting, the notion that somehow they were cheating drew great ire from fans at all levels of the game. This cheating not only reflects poorly on the moral integrity of the players choosing to cheat, but it also forces non-users who wish to remain competitive to contemplate cheating. This reinforcing escalation is at the heart of the PED problem in MLB.

Another problem with use of PED's is that no one knows the long-term negative effects. We do know the major side effects of steroid use include an increased risk of cancer, increased risk of heart and liver disease, jaundice, fluid retention, reduction in HDL-C ("good cholesterol"), high blood pressure, changes in blood coagulation, increased risk of atherosclerosis, swelling of the soft tissues of the extremities (edema), and obstructive sleep apnea. Side effects specific to men can include testicular atrophy or the shrinking of the testicles, reduced sperm count, infertility, baldness, and the development of breasts. (Drug Enforcement Administration, 2004; Hartgens & Kuipers, 2004) It is arguable whether medical intervention can reverse these effects. If users inject the drug, they are at risk for infection with HIV if they share needles, and there is a chance of getting hepatitis if they use dirty needles. A recent study by the American Heart Association showed that the left ventricle, the heart's main pumping chamber, was significantly weaker during contraction (systolic function) in participants who had taken steroids compared to a group of similar non-steroid users. (Baggish, et al., 2010) These documented health risks are rather clear-cut, but they take time to develop. Given the short careers of professional athletes, and the intense competition they experience to make it to MLB, it is very difficult for a player to look past the immediate financial and social gains and see the long-term risks of taking steroids.

The challenge for MLB in eradicating steroid use has largely been self-inflicted. Though MLB has listed steroids as a banned substance since the early 1990's, the league and the players union only agreed on random testing in 2003. (Mitchell, 2007) Though theirs was a controversial assertion, some pundits suggest that use of steroids was rampant. Some said as many as 60 percent of players were using, and the league's players, owners, and the members

of the press who covered them, reinforced a culture of selective ignorance. More recently, resistance to eradication of PEDs has arisen from the players' union, which refuses to allow its members to submit to tests that involve drawing blood. This has given rise to the use of human growth hormone (HGH). (Mitchell, 2007) Therefore, in essence, one PED has replaced another.

The present paper will address some of the fundamental forces driving steroid use in the MLB. Though there is no readily apparent easy answer, we do make some policy recommendations for MLB, which we suggest as starting points for applying leverage in the right places.

Reference Modes

The time horizon for this study is roughly 60 years, starting in 1950 and ending in 2010. The challenge with this particular topic is that nobody actually admits to using steroids (save those few looking to make money in a book deal after their careers have collapsed). These reference modes are our general estimate given anecdotal evidence, as well as, the Mitchell Report, which was a rather comprehensive look into the use of PEDs in MLB.

In the Figure 1, we estimate that growth of steroids in MLB has an exponential shape starting in the 50's and growing through 2002. MLB instituted mandatory testing in 2003 and fines and suspensions become more severe in 2005. What this chart does not show is the possible growth of HGH use, which is still not tested, and for which investigators have discovered very little evidence.

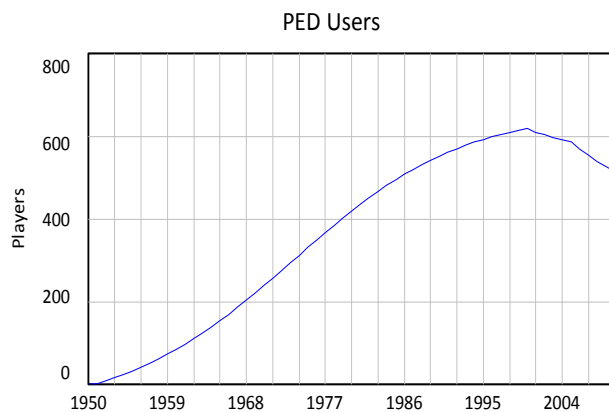


Figure 1. Performance Enhancing Drug Users

Performance is very challenging to measure. For this research, we selected home runs.¹ The challenge with home runs is that the measure excludes a population of players, pitchers, whom many considered equally likely to have been using steroids. If this is the case, then stronger pitching may have offset stronger hitting, thereby keeping home runs at the normal historical average. Given the McGuire and Sosa race, and given how Barry Bonds (who was widely thought to be using PED's) broke Hank Aaron's lifetime home run record, we

selected this performance statistic because of the ease of understanding, and the national coverage it garners. Figure 2, Total Home Runs, does show growth, but it fails to reflect that

¹ Home runs in baseball occur when a batter hits a pitched (i.e., thrown) ball over the fence in fair territory on a baseball field. The batter who does so may then run around the game's four bases at his leisure, arriving back at "home plate," which gives this hit its name. Obviously, home runs are much likelier when batters are stronger.

the number of teams and the roster sizes have changed throughout the 60-year period. Still, there is a general rise in total league home runs that could suggest steroid use.

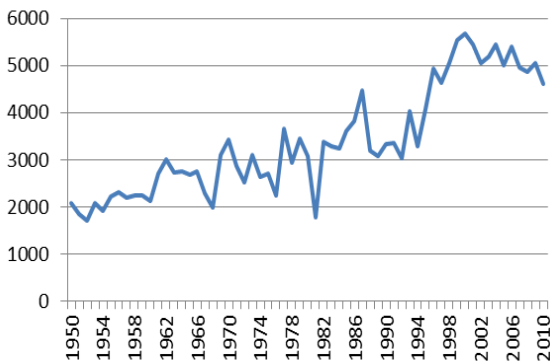


Figure 2. Total Home Runs in MLB, 1950-2010

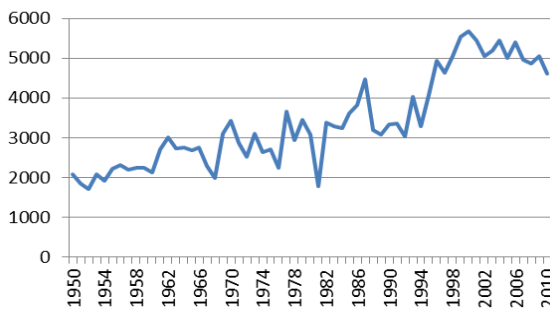


Figure 3 Average Home Runs per Batter, 1950-2010

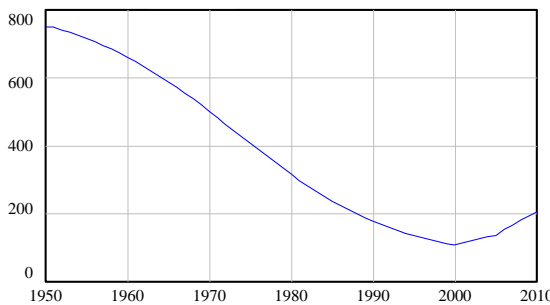


Figure 4. Potential PED Users

Not surprisingly, if overall system performance increases, it is a logical leap to suggest that average player performance increases. This is important for our model because one of the driving forces for PED use escalation is the perception of comparison between oneself and another player. Figure 3 shows average home runs per player over the 60-year period. This statistic controls somewhat for the change in number of players and number of games over the sixty-year period, and it shows growth in number of home runs per player from 1992 to 2001.

At very specific points in time, MLB instituted policy measures to thwart steroid use. The measures primarily consisted of testing standards and intervals, and rules governing the punishment for incremental positive tests. MLB started testing in 2003 and raised the testing protocol and punishments in 2005. (ESPN, 2007) This last policy measure is where we think players began looking at other PEDs, like HGH, for alternatives to anabolic steroids.

Figure 4, "Potential PED Users," is useful in that it suggests a large number of the susceptible population actually began using steroids. When we examine the model, it will become evident that there are two reinforcing loops that are free to run for many cycles before any balancing loops come

into play. This tends to reflect the rumored usage rate of 60 percent. We will begin our examination of dynamics of this situation with the full causal loop diagram, which we show in Figure 5. We will follow that with discussions of subsections of and important loops in that diagram.

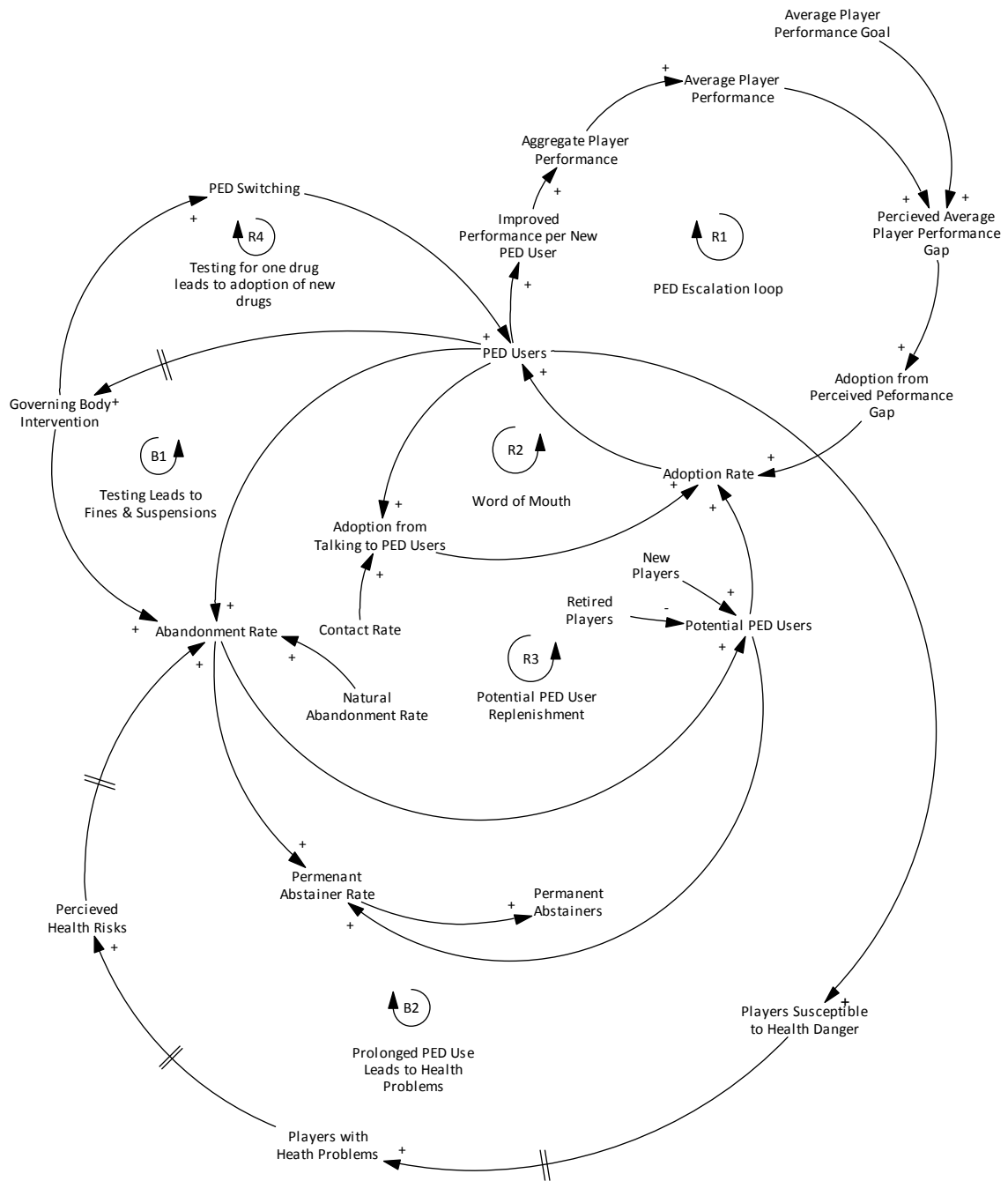


Figure 5. Overall Causal Loop Diagram

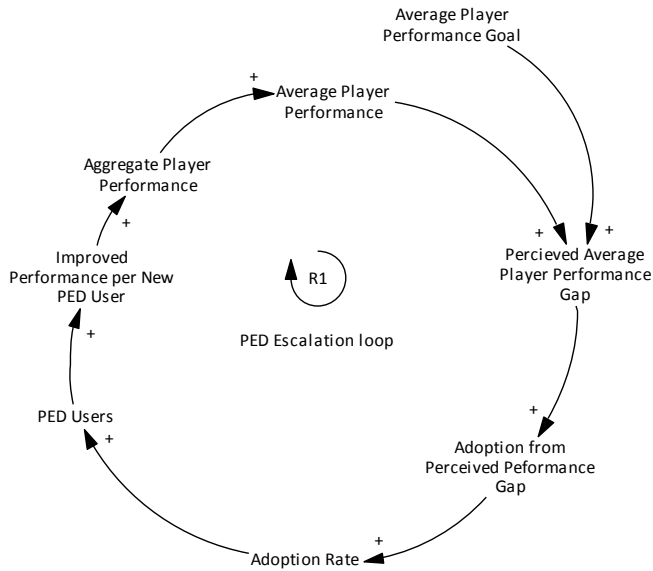


Figure 6. Loop R1 – PED Escalation

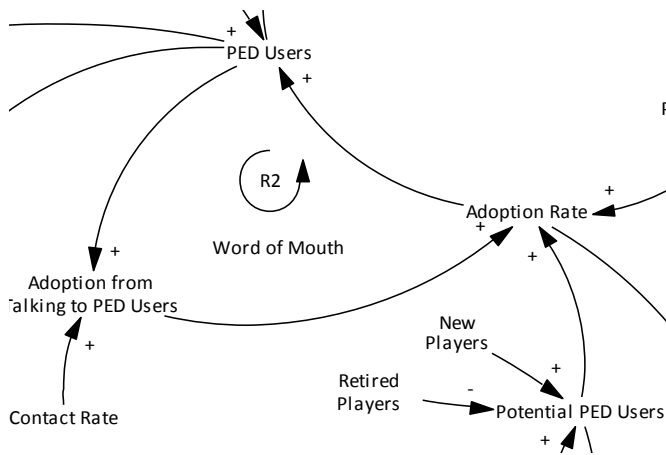


Figure 7. Loop R2 – Word of Mouth Escalation

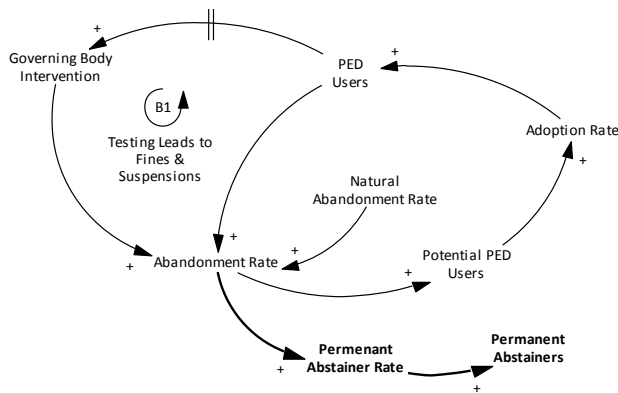


Figure 8. Loop B1 – Testing, Fines, and Suspensions

As we will discuss later, the underlying structure of this problem is the Bass Diffusion Model (Sterman, 2000), where the stock non-using players adopt PEDs and flow into the stock of users. Several loops in the diagram illustrate how this happens.

In the R1 loop (Figure 6), “PED Escalation,” the key driver is players comparing themselves to the average player’s performance. In this case, players leave the pool of potential users and become users—if they perceive themselves as falling behind the average performance level.

As in the Bass Diffusion Model, players may also begin using PEDs if they find out from fellow players that the drugs can actually enhance performance. In this scenario, which we show in the “Word of Mouth” loop in Figure 7, Potential Users interact with PED Users at some given contact rate. Each contact contributes to new adoption, providing more users to the system, which drives up both the R1 and the R2 loops.

The key to loop B1, “Testing Leads to Fines and Suspensions” (Figure 8), and to the system’s behavior, is the delay between PED Users and Governing Body Intervention. In our estimates, it took MLB forty years from the start of our time horizon to acknowledge steroids as a banned substance. Another thirteen years went by before it implemented testing.

The “Potential PED User Replenishment” loop (R3, Figure 9) is straightforward: some players who abandon do not quit *permanently*. Like smokers addicted to nicotine, some PED users who quit may miss the feeling of power and the improved performance that allegedly comes with PED use. Those players again become Potential PED Users, and some elect to use again. (A fraction of those who abandon choose to abstain permanently, which we depicted earlier in boldface along the bottom of the diagram in Figure 8.)

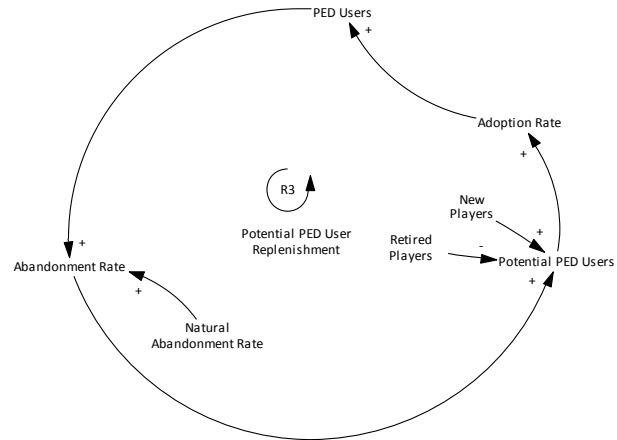


Figure 9. Loop R3 – Abandonment and Replenishment

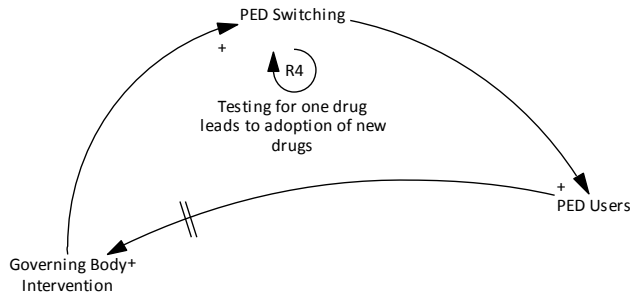


Figure 10. R4 – PED Switching

We do not have any data on users switching from steroids to HGH, as depicted in Figure 10, the reinforcing loop R4. However, the Mitchell Report (Mitchell, 2007) hints at switching, and anecdotal evidence suggests it is a real possibility. The switching that occurs in other sports, like cycling, also presents a basis for comparison. Other than the selective ignorance we have already mentioned, this is a significant point of

policy resistance. Though we did not present it in our model, the collective bargaining agreement between the league and the players’ union, the Major League Baseball Players Association (MLBPA), really helps facilitate this by taking a very strong stance against blood testing. Until MLB and the MLBPA can come to terms on a more pervasive testing culture, PED switching will continue, and will likely have adverse health effects on the players they are trying to protect.

The major component of loop B2 (Figure 11), as in B1, is the long delay. Where players are so focused on the short term payout, the longer term dangers of prolonged PED use get brushed aside. Unfortunately, it is going to take a very high profile health issue, like death, to snap players out of their money fog and realize PEDs are very, very dangerous.

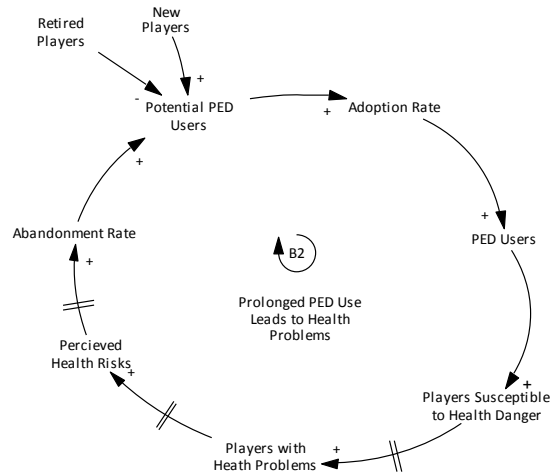


Figure 11. Loop B2 – Health Problems

System Dynamics Model

We converted part of the causal loop diagram into a system dynamics model, which we show in Figure 12. This model is a variant of the Bass Diffusion Model (discussed at length in Sterman, 2000). The model we used is very rough, and has several weaknesses. The biggest weakness is that it uses a fixed number for Players in the System, when we know that MLB baseball expanded greatly over the sixty years of this time horizon. It also uses a constant for Home Runs per Player per Year, when we know that this average crept up during the period in question. Therefore, results from the present study should be taken as preliminary.

In this model, Potential PED Users adopt them and become PED Users. We focused primarily on adoption rates as driving by perceived performance gaps and word of mouth. We created a user life cycle stock and flow, and looked at drivers of both adoption and abandonment. Finally, we examined the effect of use on performance, specifically home runs, through a co-flow. Because of the long delay, we excluded health risks as a driver of permanent abstention. We will cover some of the key highlights here before we move on to a policy discussion.

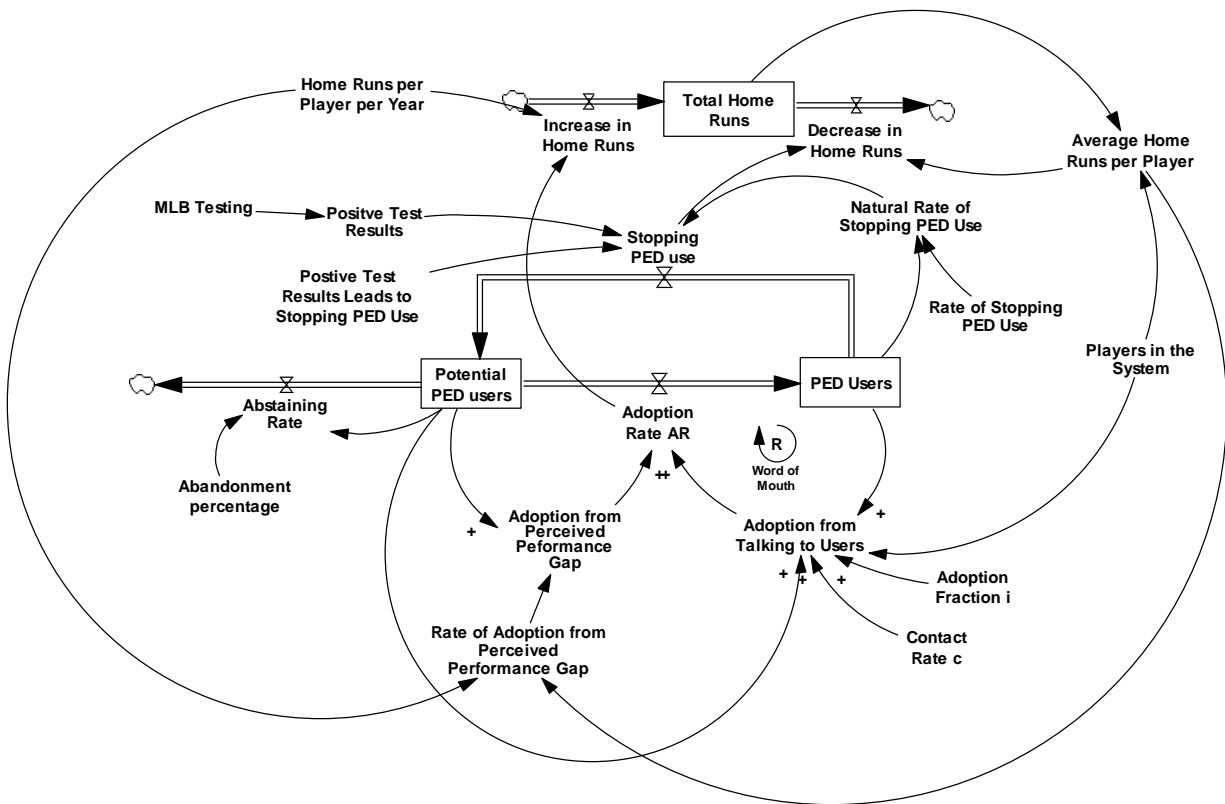


Figure 12. A System Dynamics Model of the Performance Enhancing Drugs (PED) Problem

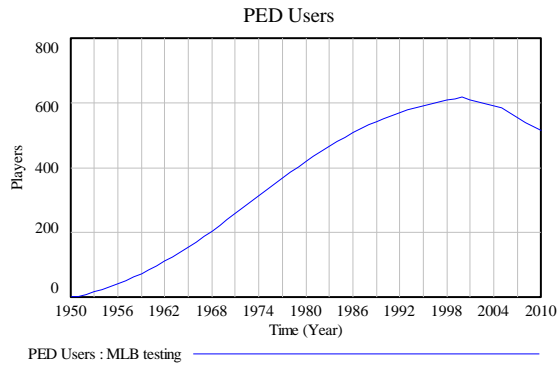


Figure 13. Number of PED Users

100 out of 750 players were not using (see Figure 14).

Finally, when we examine our model's output relative to real data (actual league home runs per year), which we show in Figure 15, we are encouraged to see we captured the general trend. However, we clearly missed on a few points, including the oscillation that appears, and that the number of teams and players has increased over the period.

Firstly, as expected, the usage rates starting at time zero (1950) grow exponentially until the first and second MLB interventions, which occur in 2000 and 2005, as shown in Figure 13.

Secondly, the stock of potential PED users drains quite quickly. We first thought this was excessive, but given some of the anecdotal evidence, we have reason to suspect this pattern is not entirely off base. By the mid to late 1990s, our model suggests only around

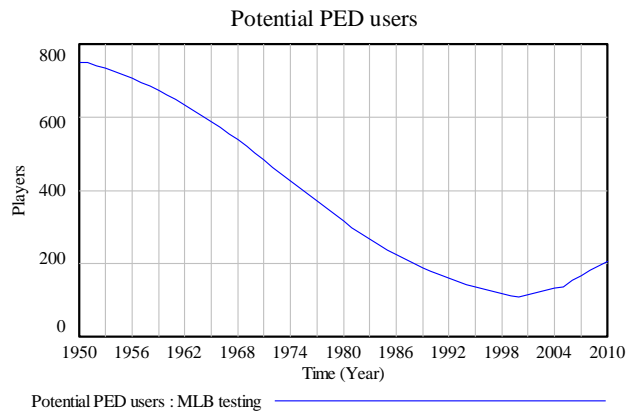


Figure 14. Potential PED Users

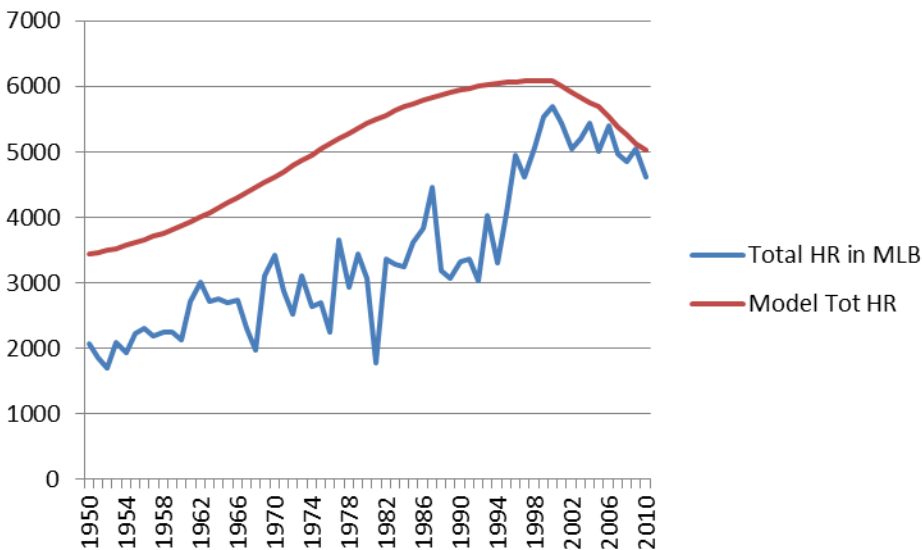


Figure 15. Total Home Runs, Model vs. Actual Data

Policy Analysis

When looking at the policies MLB has implemented to combat PED use, two things stand out. First, the culture of selective ignorance in all levels of the system absolutely contributed to the exponential growth in steroid use. Second, MLB has been manhandled by the MLBPA in negotiating real and meaningful testing policies to prevent future types of PEDs from entering the system. However, the policies have been effective in at least setting the groundwork for more policies and more testing. And, when faced with the realization of how pervasive steroid use was, MLB took immediate steps to increase the penalties. In 2002, the penalties consisted of 5 allowable positive tests, with the fifth positive test a discussion with the commissioner. By the end of 2005, the league had instituted a new penalty scale (the second one that year) consisting of three positive tests, with the third positive test a lifetime ban. We think this newer scale has had a significant effect on steroid use. However, we are not certain it has really forced PEDs out of baseball, since testing is very limited in the current collective bargaining agreement.

So, what else can MLB do? The penalty scale could go down to two or one positive test, but that presents a steep penalty for the real, though small, percentage of tests that generate false positives. And, in the current Collective Bargaining Agreement environment, we are not sure how much that would stop other PEDs.

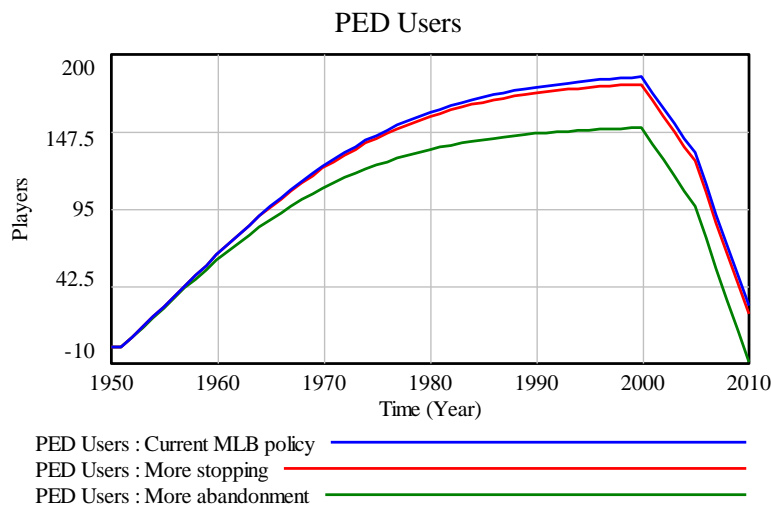


Figure 16. Effect of Different PED Reduction Policies

the current policy, a policy where double the players temporarily stop using after testing (called “More Stopping”) and a policy where the rate of permanent abstention goes from 5% to 6% after learning about the adverse long-term health effects (called “More Abandonment”). Figure 16 shows that the improvements from doubling the amount of temporary stopping are modest; however, increasing permanent abandonment by 20 percent (from 5% to 6%) has a much greater effect.

Ultimately, we think the real leverage is in renegotiating with the MLBPA to institute a flexible policy that will adapt to the PED market and allow the league to institute testing in a real and

meaningful way. Until then, PED switching will likely continue to drive usage and keep relatively high the percentage of players using.

Future research

PED usage in Major League Baseball is a big problem for the league, and we think it is worth refining the current model to make policy analysis more effective. We expect to continue working to improve and refine the present model.

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