The Carrot and the Stick: Cleaning up PED Use in Minor League Baseball

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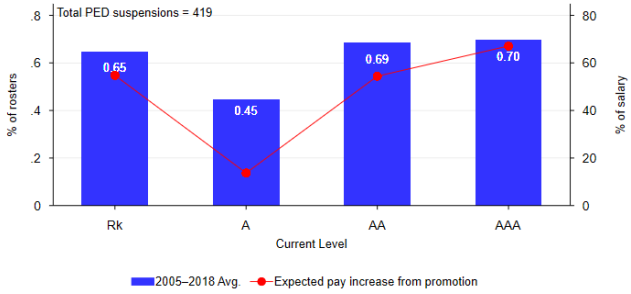
Motivation

- MLB's Joint Drug Prevention and Treatment Program is now almost 20 years old!
- The prevention program has been a clear success with very few MLB players suspended for PED use in recent seasons.
- Despite these improvements, it was less clear how successful drug prevention was at the MiLB level…at least until very recently.
- Back in March 2020, my coauthor presented research at SABR that suggested a link existed between *the pay structure of MiLB and PED use*.

Motivation

- ***The main argument***: At the margins of each minor league level, there were potentially large gains from even small increases in performance, creating an incentive for PED use even after taking into account penalties for being caught.



Motivation

The clear pattern between PED suspensions and the expected pay increase from promotion in the old MiLB suggested a possible way to reduce PED use…

Adjusting the MiLB Pay Curve

- The 2022-2023 seasons saw a significant change to the MiLB base wage schedule that made it both higher *and* flatter across all levels.
- There has also been a substantial decline in MiLB PED suspensions (even after taking into account the contraction in MiLB teams in 2020/2021).

Research Question

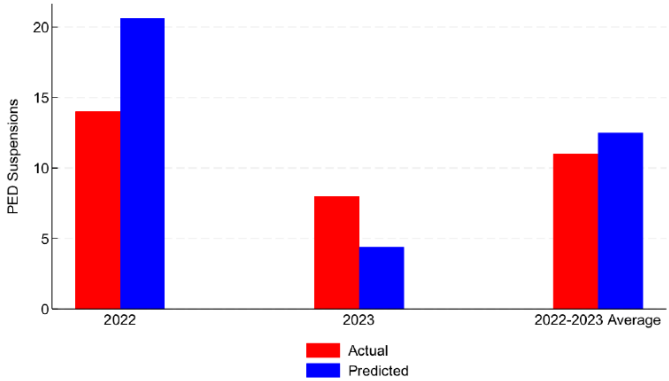
Given these recent changes in MiLB pay and PED suspensions, we ask 2 questions...

1. Are the two developments linked as we thought they might be in 2020?
2. What implications does this have for mitigating future PED use in MiLB?

To answer these questions we…

- Formalize and calibrate a game theoretic model of how MLB can alter the incentives faced by the marginal PED-using player at each level of MiLB and, hence, their likelihood of PED use, with both ***"carrot"*** and ***"stick"*** type policies.
- We show that…
  1. Both the *level* and the *slope* of the pay curve matter for MiLB PED use!
  2. The model predicts the decline in PED use for the 2022-2023 seasons quite well.

Preview of Results



The Player's Problem: Expected Benefits to PED Use

- A player must choose whether or not to utilize PEDs, $PED \in \{0, 1\}$.
- Utilizing PEDs alters the probabilities for transitioning from his current playing level, n. We have probability matrix, $P_n(PED) \equiv P_n(PED = 1) - P_n(PED = 0)$.
- A transition to a higher level is associated with a pay increase, Δw.
- The *expected benefits to PED use* can then be written as:

$$P_n(PED) \cdot \Delta w$$

The Player's Problem: Expected Cost to PED Use

- However, PED use comes with a cost. If he is caught, he loses his current wage, w_n, for a fraction of a season's games, s_n.
- Players have differing views on the probability of being caught using PEDs, ρ_n.
- This can be thought of as a proxy for the ability to mask PED use.
- Player-level variation in ρ_n adds to level variation in the *expected cost of PED use*:

$$\rho_n s_n w_n$$

The Player's Problem Formalized

- Taking the expected benefits and costs to PED use at each MiLB level, the player's problem can be modeled as:

$$\max_{PED \in \{0,1\}} \underbrace{P_n(PED) \cdot \Delta w}_{\text{expected benefits}} - \underbrace{\rho_n s_n w_n}_{\text{expected cost}}$$

- A player will choose to use PEDs if the *net expected return*, $R(\rho_n)$, is positive:

$$R(\rho_n) = \underbrace{[P_n(PED = 1) - P_n(PED = 0)] \cdot \Delta w}_{\text{expected benefits}} - \underbrace{\rho_n s_n w_n}_{\text{expected cost}}$$

The League's Problem

- Testing is costly and the league cannot test to the point that the net return to PED use is negative for all players at all MiLB levels.
- This creates an *incentive compatibility constraint*, whereby the margin of PED use at each level is chosen by the league such that $R(\rho_n^*) = 0$.
- How does the league achieve $R(\rho_n^*) = 0$? Through its choice of suspension, s_n, and salary schedules, w_n & Δw.
- In our model, we take both $P_n(PED)$ and s_n as given. Thus, the only choice variables from the league's perspective are salary determinants: w_n and Δw.

The League's Problem Formalized

The league's *minimax* problem is summarized as:

$$\min_{\{w_n, \Delta w\}} \left[\max_{PED \in \{0,1\}} P_n(PED) \cdot \Delta w - \rho_n s_n w_n, 0 \right]$$

which reduces to incentive compatibility, or

$$R(\rho_n^*) = \underbrace{[P_n(PED = 1) - P_n(PED = 0)] \cdot \Delta w}_{\text{expected benefits}} - \underbrace{\rho_n^* s_n w_n}_{\text{expected cost}} = 0$$

where ρ_n^* identifies the suspension beliefs in each level for the player at the acceptable margin of PED use for the league.

Solving the Model

In equilibrium, PED use results from the league minimizing the maximum return to PED use by altering the beliefs of the marginal PED-using player at each level (ρ_n^*).

This is summarized in what we term the ***marginal willingness-to-pay for PEDs (MWP)***:

$$MWP \equiv \underbrace{\rho_n^* s_n}_{\text{expected \% loss in salary from PED use}} = \underbrace{[P_n(PED = 1) - P_n(PED = 0)] \cdot \frac{\Delta w}{w_n}}_{\text{expected \% gain in salary from PED use}}$$

For players where $\rho_n < \rho_n^*$, the *net expected return to PED use* is positive & $PED = 1$.

The PED Policy Levers

The MWP makes clear that there is more than one lever to pull to influence PED use.

We categorize these methods as ***"carrots"*** and ***"sticks"***.

1. ***Carrots***: w_n & Δw (the MiLB pay curve)
2. ***Sticks***: $P_n(PED)$ & s_n (transitition probabilities & suspension lengths)

Early PED policies operated primarily through "sticks", mostly suspension lengths.

But they can be very costly to both the league and its teams.

That's likely why we have a 3 strikes and you're out policy.

Key Implications for Carrot Policies

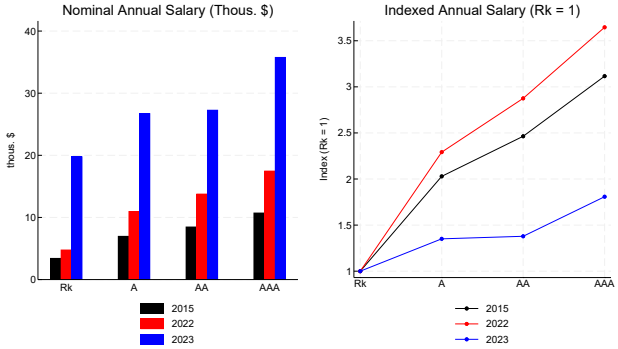
Taking the sticks as given and focusing on the carrots, there are two implications:

$$\rho_n^* s_n = [P_n(PED = 1) - P_n(PED = 0)] \cdot \frac{\Delta w}{w_n}$$

1. An increase (decrease) in the slope of the wage schedule, Δw, increases (decreases) the percentage gain in salary from PED use and MWP.
2. An increase (decrease) in the wages of a given league, w_n, decreases (increases) the percentage gain in salary from PED use and MWP.

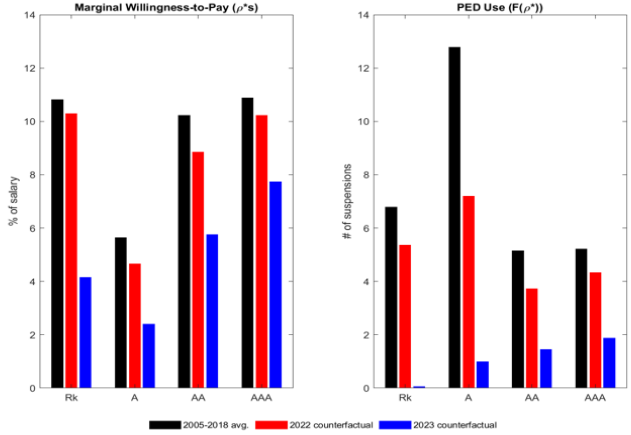
We test these implications using what happened to the MiLB pay curve in 2022-2023.

The MiLB pay curve, w_n and Δw

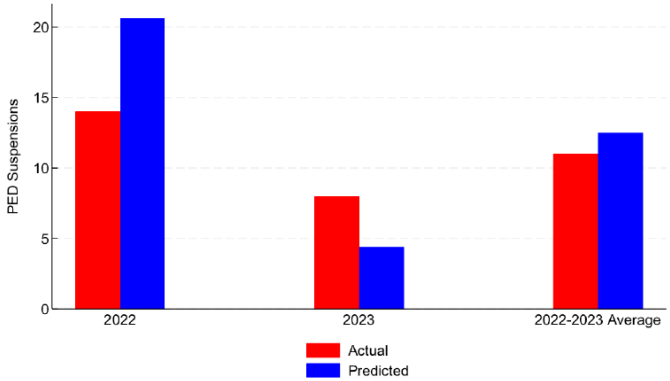


1. 2022 sees an *increase* in w_n and slight *increase* in Δw.
2. 2023 sees an *much larger increase* in w_n and a *decrease* in Δw.

Estimated $\rho_n^* s_n$ and PED Suspensions



Actual and Predicted PED Suspensions, 2022-2023



Implications

1. Provided a framework that shows how MLB can alter the actions of the marginal PED-using player in MiLB through ”carrot” and ”stick” type policies.
2. Highlighted how changing pay in MiLB impacts PED use:
   $\rightarrow$ Higher wages *and* narrower wage differences across levels are deterrents.
3. *Caveats:*
   - ***Have we fully accounted for the costs and benefits of PED use?***
     Match the overall decline, but over/under predict it at the lower/higher levels
     Perhaps we need to account for subsidies? Or, other costs to PED use?
   - ***Have we pulled all the levers?***
     If $P_n(PED = 1) - P_n(PED = 0)$ were to shrink, we predict further decline in PED use
     But this would require penalties at the *team level*.

Transitions between levels by PED testing status, $P_n(PED)$

- We isolate the effect of PED use on level transitions in the model, $P_n(PED = 1) - P_n(PED = 0)$, using nearest-neighbor multivariate distance matching without replacement (Jann, 2017) on minor league player profiles from Baseball Reference merged with MiLB PED suspensions. We match 227 of 419 suspensions from 2005-2018.
- Insufficient data exists to be able to estimate transitions for the more recent seasons capturing the new MiLB regime, particularly given the lost 2020 season and abbreviated 2021 season.

Transitions between levels by PED testing status, $P_n(PED)$

A. Matched control sample, $P_n(PED = 0)$

Current Level	Next Season Level						
	Out	*Fgn Rk/Ind*	*Rk*	*A*	*AA*	*AAA*	*MLB*
Rk	0.20	0.04	0.29	0.42	0.03	0.02	0.00
A	0.18	0.06	0.02	0.49	0.19	0.06	0.00
AA	0.18	0.12	0.01	0.06	0.25	0.28	0.10
AAA	0.17	0.12	0.00	0.03	0.16	0.37	0.15

Figure: Probability Matrix of Non-PED-Using Player

Transitions between levels by PED testing status, $P_n(PED)$

B. Matched treated sample, $P_n(PED = 1)$

Current Level	Next Season Level						
	Out	*Fgn Rk/Ind*	*Rk*	*A*	*AA*	*AAA*	*MLB*
Rk	0.23	0.01	0.30	0.42	0.01	0.02	0.01
A	0.21	0.05	0.02	0.52	0.14	0.04	0.01
AA	0.11	0.14	0.00	0.04	0.39	0.26	0.06
AAA	0.21	0.09	0.00	0.01	0.10	0.45	0.13

Figure: Probability Matrix of PED-Using Player

The marginal willingness-to-pay for PEDs, $\rho_n^* s_n$

- We set s_n to the average PED suspension length at each level in our matched sample for the old MiLB.
- We set the distribution of beliefs to follow a Beta distribution: $\rho \sim Beta(\alpha, \beta)$

League	ρ_n^*	$\bar{\rho}_n$	σ_ρ^2	s_n
Rk	0.15	0.47	0.02	0.71
A	0.12	0.64	0.04	0.47
AA	0.27	0.93	0.02	0.38
AAA	0.32	0.91	0.02	0.34

Figure: While the variance is similar across levels, equilibrium beliefs, ρ_n^*, and average beliefs, $\bar{\rho}_n$, vary substantially.

The pay schedule, w_n and Δw

- We obtain salary information for 2015, 2022, and 2023 from various blogs and news articles.
- We set w_n to the annual minimum for each of *Rk*, *A*, *AA*, *AAA* for all 3 years.
- We complete Δw by accounting for transitions out of MiLB:
  1. Promotion to MLB $\rightarrow$ MLB salary for 1 day of service
  2. Demotion to Foreign or Independent League $\rightarrow$ Base salary for DSL/VSL
  3. Leaving baseball $\rightarrow$ opportunity cost of pro career