

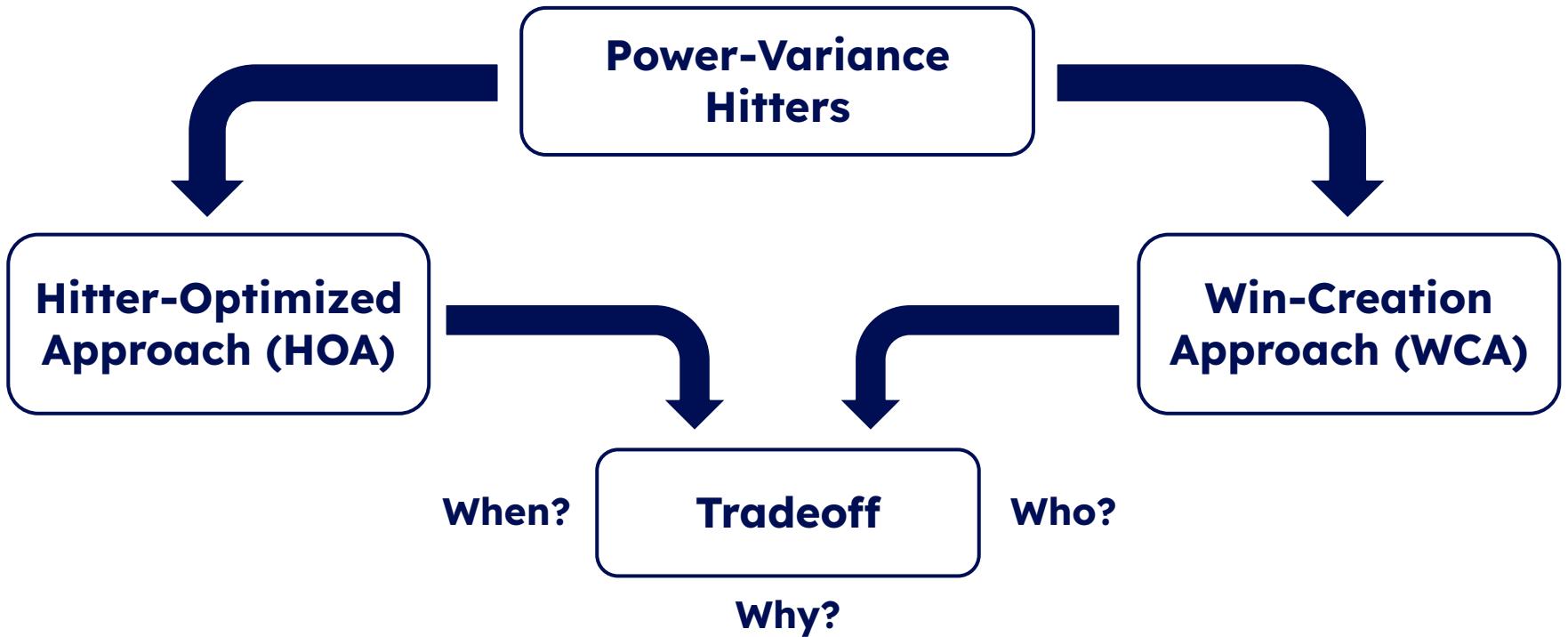
When Power Hitters Should Swing Smart

Using Markov Chain Changes in Win Probability

Ben Resnic, Andrew Diamond, Zach Levitan, Carter Pointon, Ameer Shah



Introduction

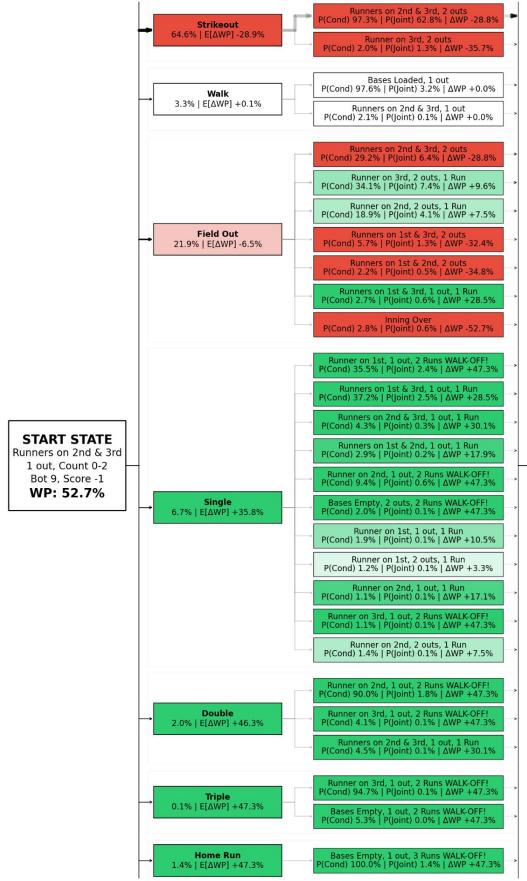


Defining A Win-Creation Approach

A **Decrease** in Bat Speed And/Or Swing Length That Leads to an **Expected Increase** in Win Probability Compared to a Hitter's Average Swing Tendency
(Hitter-Optimized Approach)

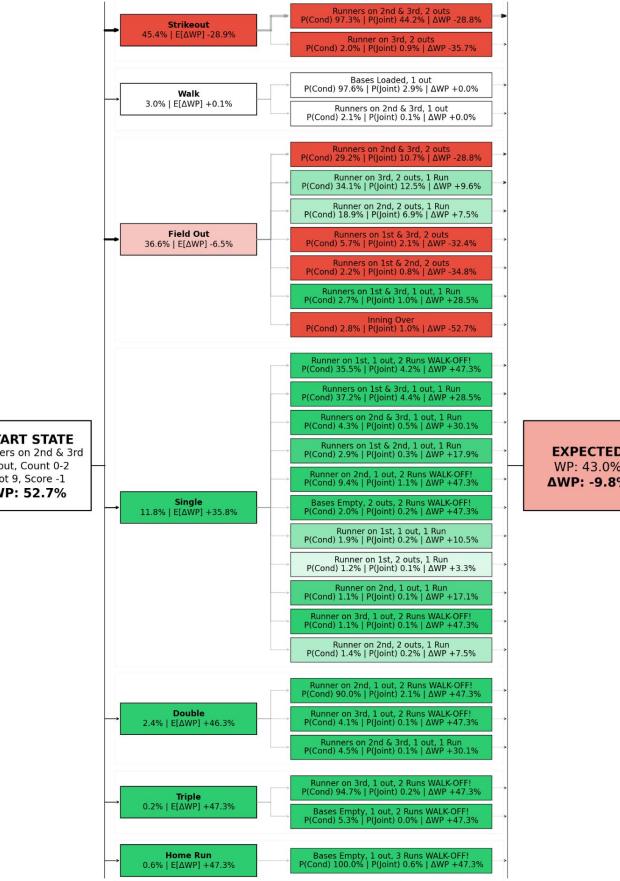
Oneil Cruz Hitter-Optimized Approach Transition Flowmap

Runners on 2nd & 3rd, 1 out | Bot 9 | Score -1 | Vs Elite Pitcher



Oneil Cruz Win-Creation Approach Transition Flowmap

Runners on 2nd & 3rd, 1 out | Bot 9 | Score -1 | Vs Elite Pitcher



**That was pretty confusing.
Let's generalize the approach**

Markov Chain Expected Change in Win Probability

Game State

Inning
Top/Bot
Score Diff
Outs
Base State
Count
Hitter Quality
Pitcher Quality

Markov Chain Expected Change in Win Probability



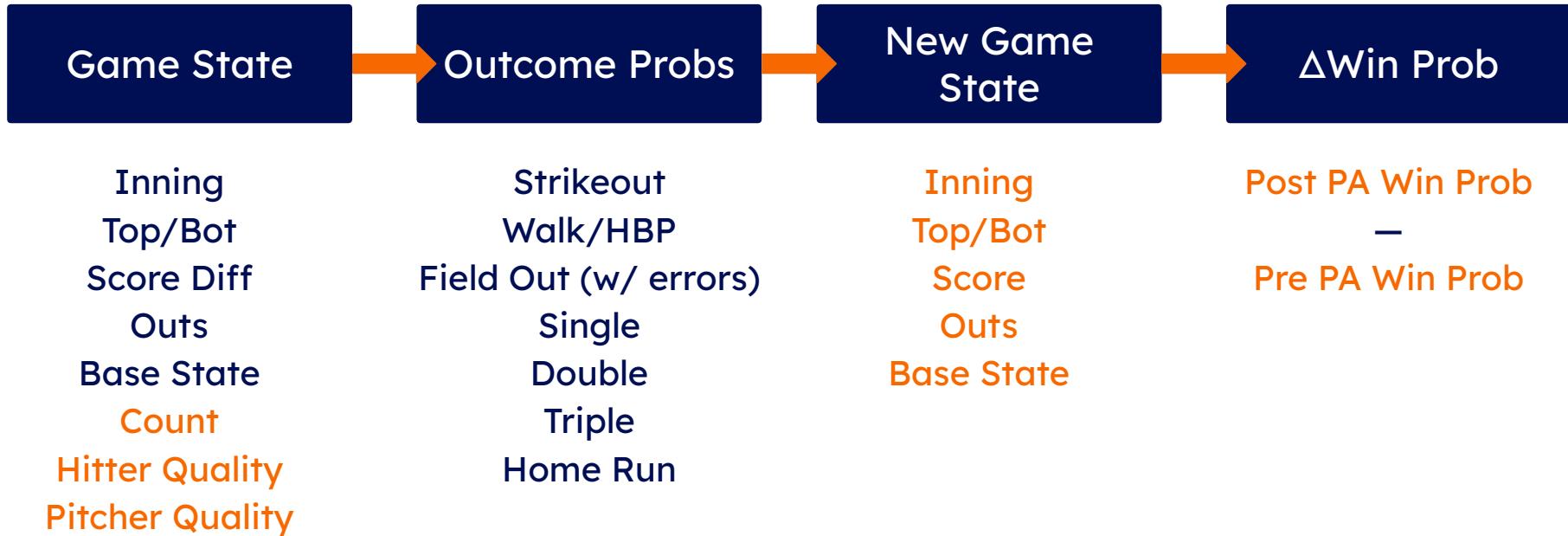
Inning	Strikeout
Top/Bot	Walk/HBP
Score Diff	Field Out (w/ errors)
Outs	Single
Base State	Double
Count	Triple
Hitter Quality	Home Run
Pitcher Quality	

Markov Chain Expected Change in Win Probability



Inning	Strikeout	Inning
Top/Bot	Walk/HBP	Top/Bot
Score Diff	Field Out (w/ errors)	Score
Outs	Single	Outs
Base State	Double	Base State
Count	Triple	
Hitter Quality	Home Run	
Pitcher Quality		

Markov Chain Expected Change in Win Probability



Getting End of Plate Appearance Outcome Probabilities

Season
Long
Averages



Outcome Probs

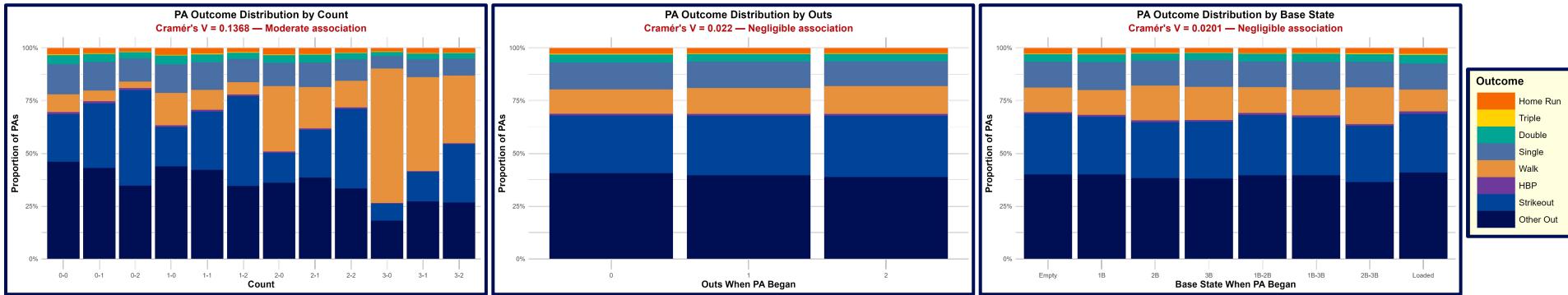
Strikeout
Walk/HBP
Field Out (w/ Errors)
Single
Double
Triple
Home Run

$$\sum_{k=1}^7 \pi_k = 1$$

Difference in Outcome Probabilities

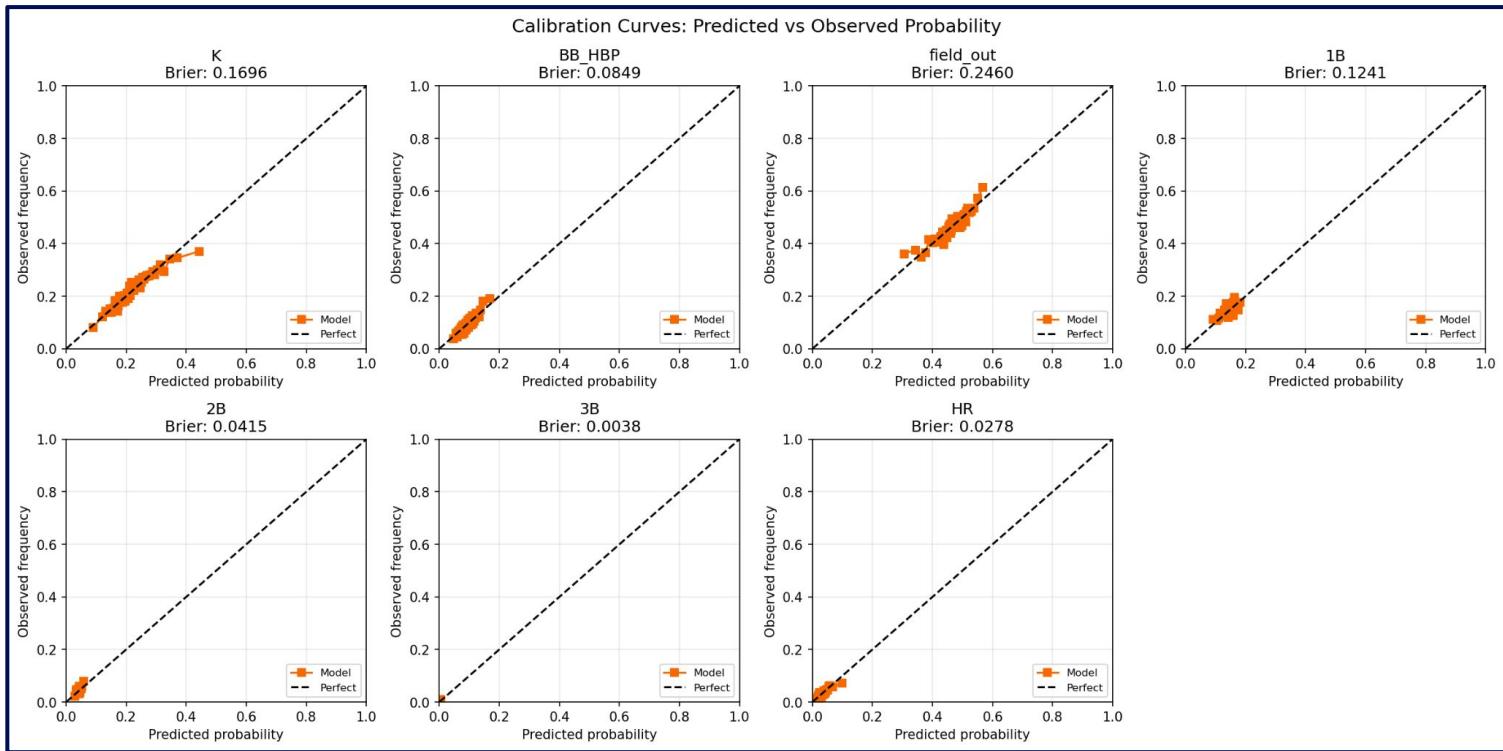
Between Count, Outs, and Base State

Cramér's V: Measures practical effect size, regardless of sample size

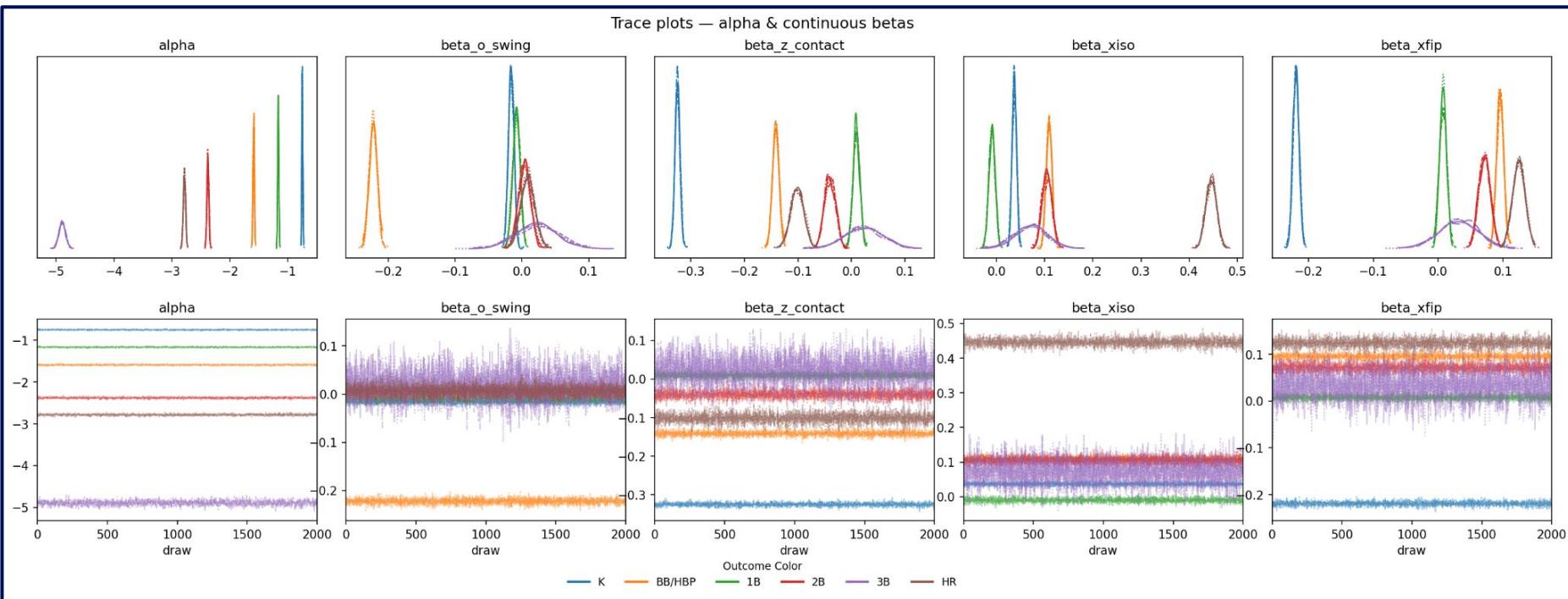


Using a **chi-square test**, probabilities change **more by count**, not so much for outs or base state

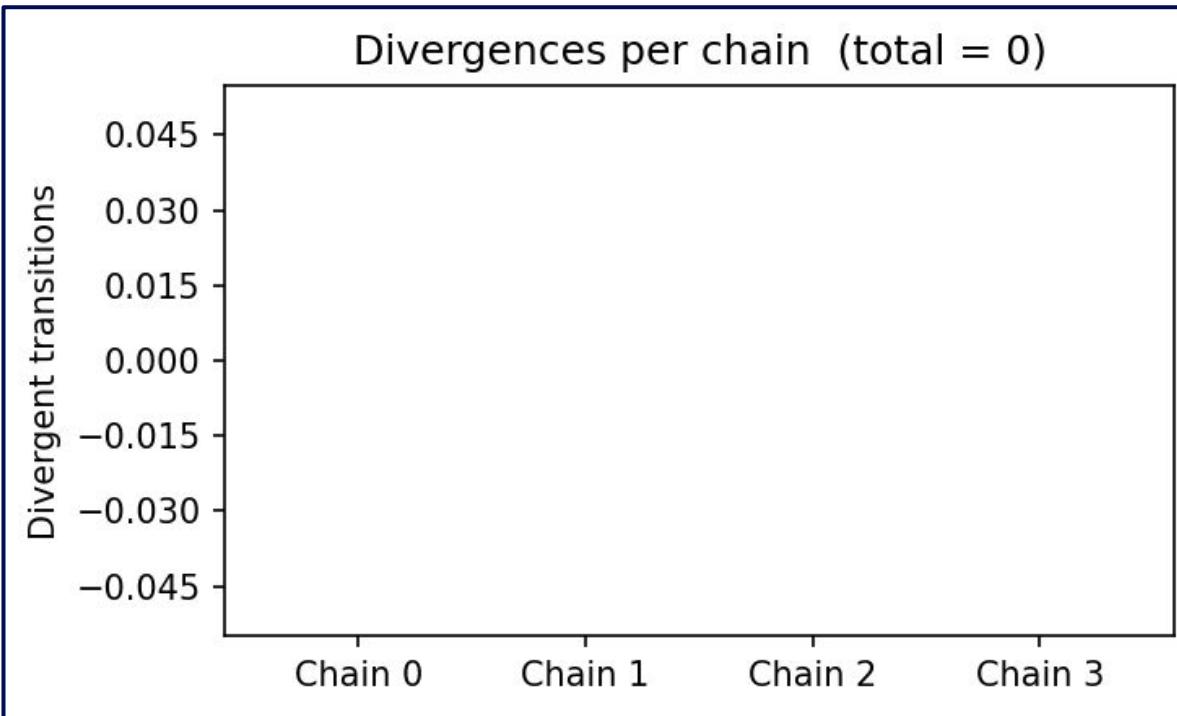
Bayesian Multinomial Logistic Regression



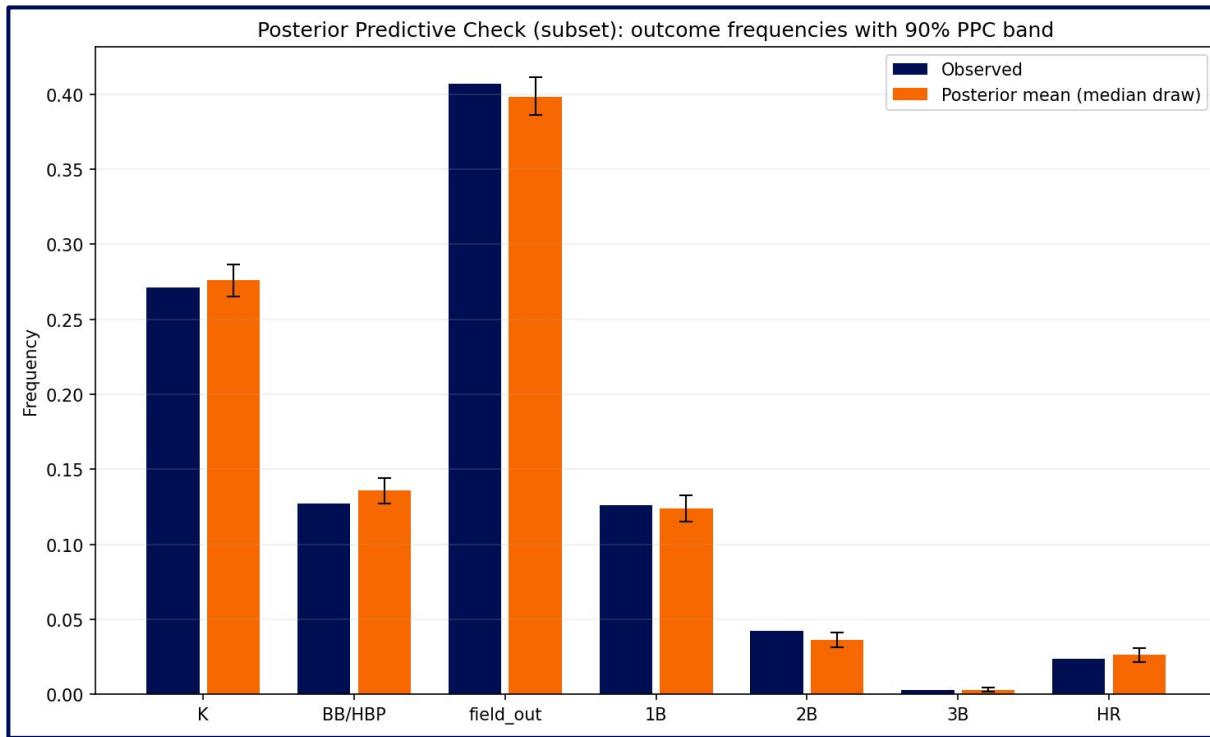
Bayesian Multinomial Logistic Regression



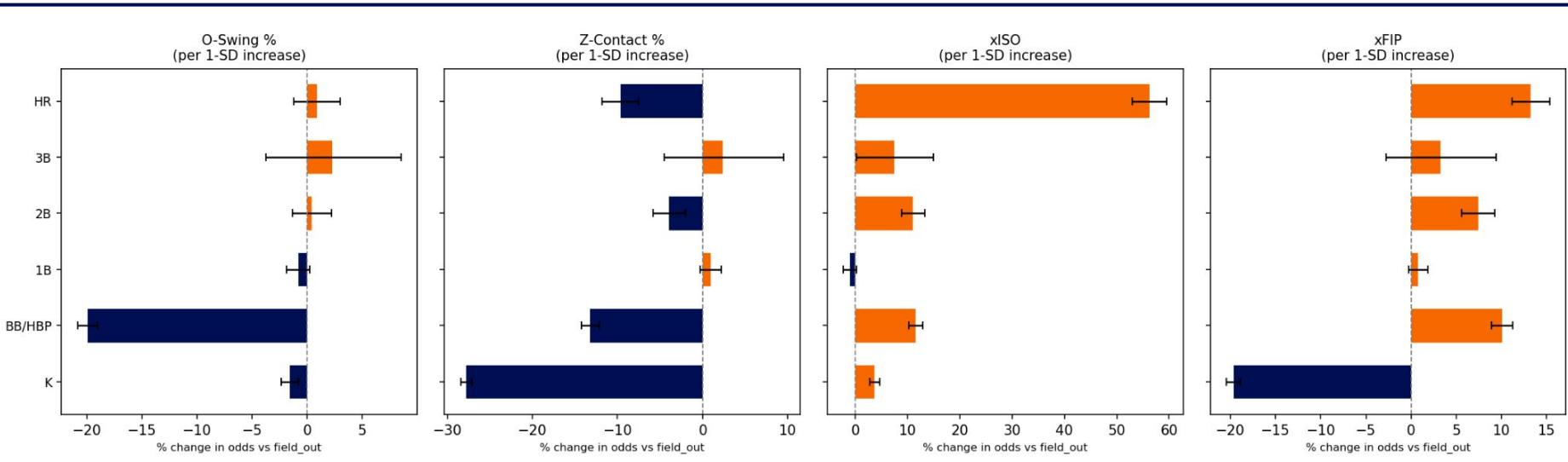
Bayesian Multinomial Logistic Regression



Bayesian Multinomial Logistic Regression



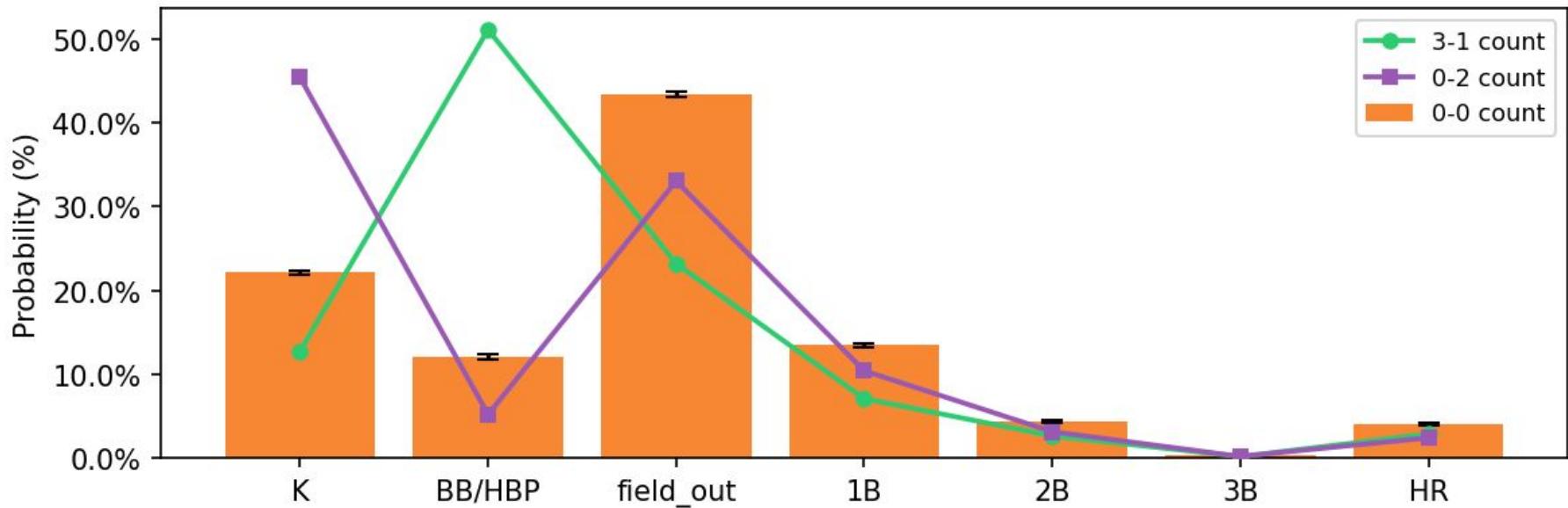
Bayesian Multinomial Logistic Regression



Bayesian Multinomial Logistic Regression

Posterior Outcome Probabilities with Hitter-Optimized Approach

O-Swing%: 25.7% | Z-Contact%: 86.1% | xISO: 0.229 | xFIP: 4.09







What if the hitter **Decreases Bat Speed and/or Swing Length?**

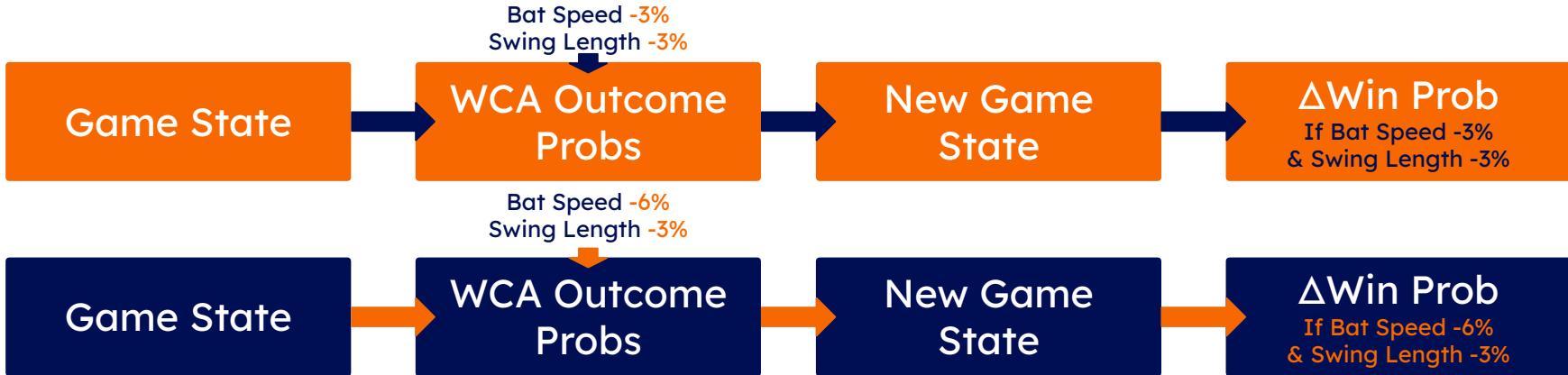


What if the hitter **Decreases Bat Speed and/or Swing Length?**



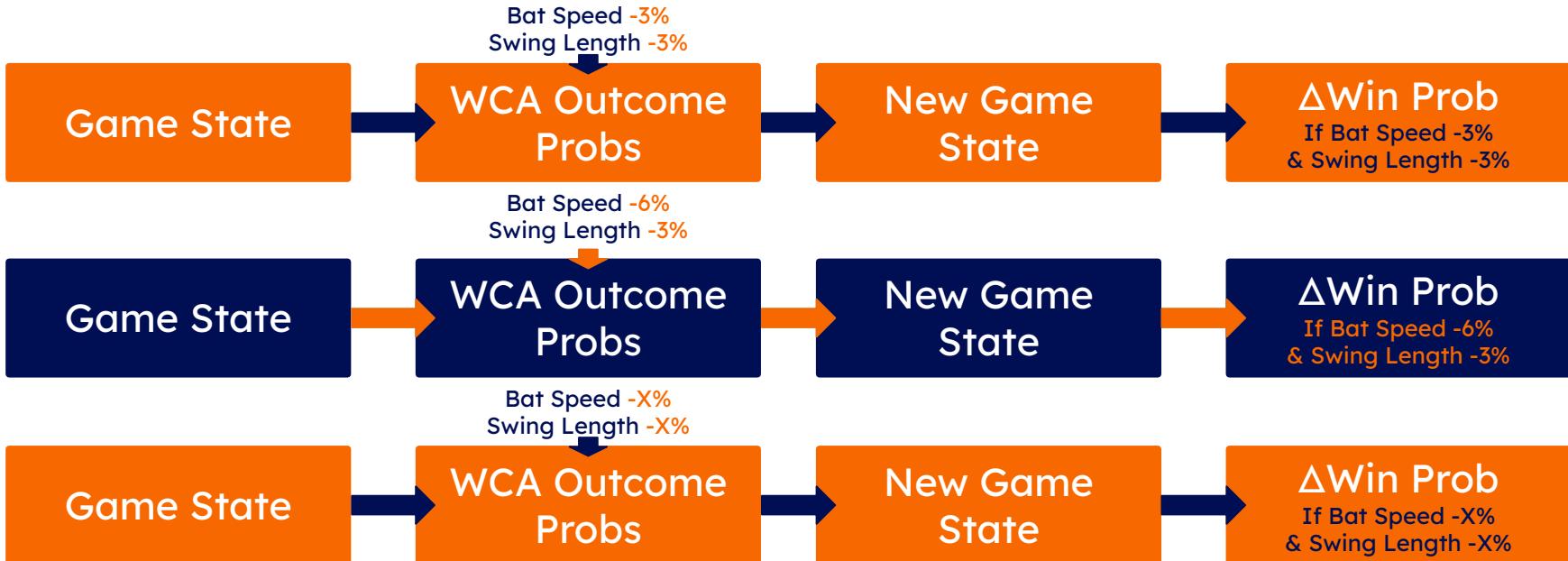


What if the hitter **Decreases Bat Speed and/or Swing Length?**





What if the hitter **Decreases Bat Speed and/or Swing Length?**



And So On and So On...

Bat Speed

-0%	-0%	-0%	-0%	-0%
-12%	-9%	-6%	-3%	-0%
-3%	-3%	-3%	-3%	-3%
-12%	-9%	-6%	-3%	-0%
-6%	-6%	-6%	-6%	-6%
-12%	-9%	-6%	-3%	-0%
-9%	-9%	-9%	-9%	-9%
-12%	-9%	-6%	-3%	-0%
-12%	-12%	-12%	-12%	-12%
-12%	-9%	-6%	-3%	-0%

Swing Length



Matchup

Outcome Pros

Hitter Quality

Pitcher Quality

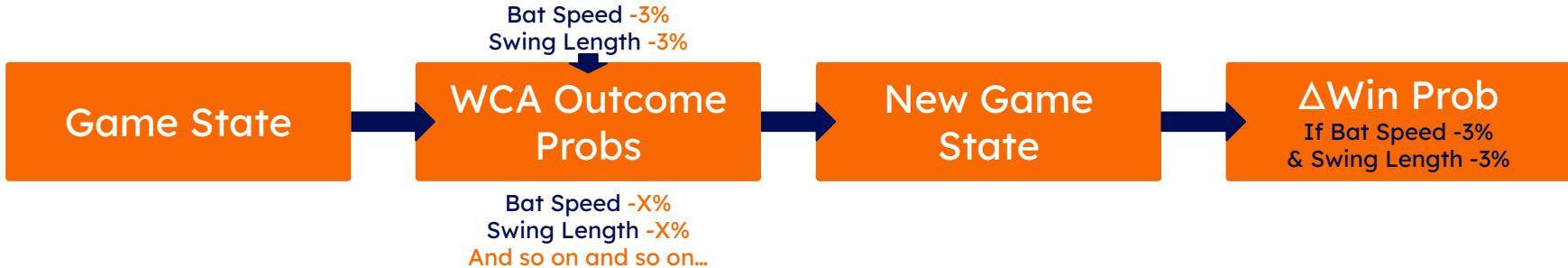
Count

Δ Bat Speed

Δ Swing Length



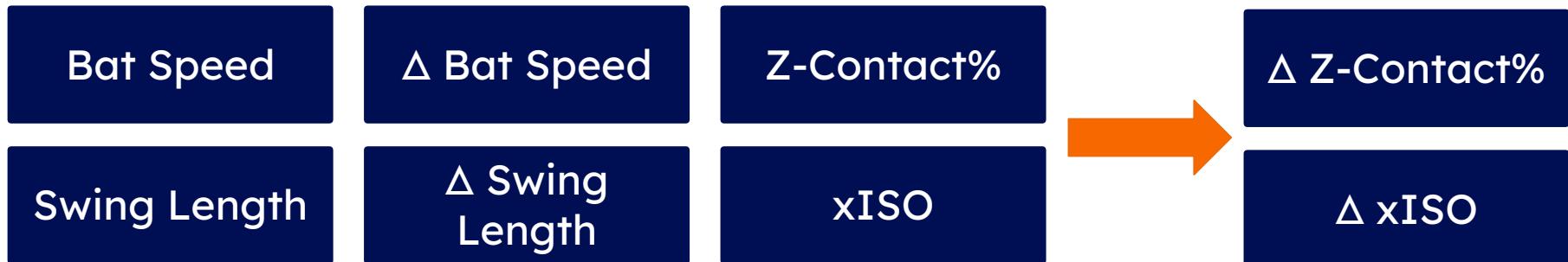
What if the hitter **Decreases Bat Speed and/or Swing Length?**



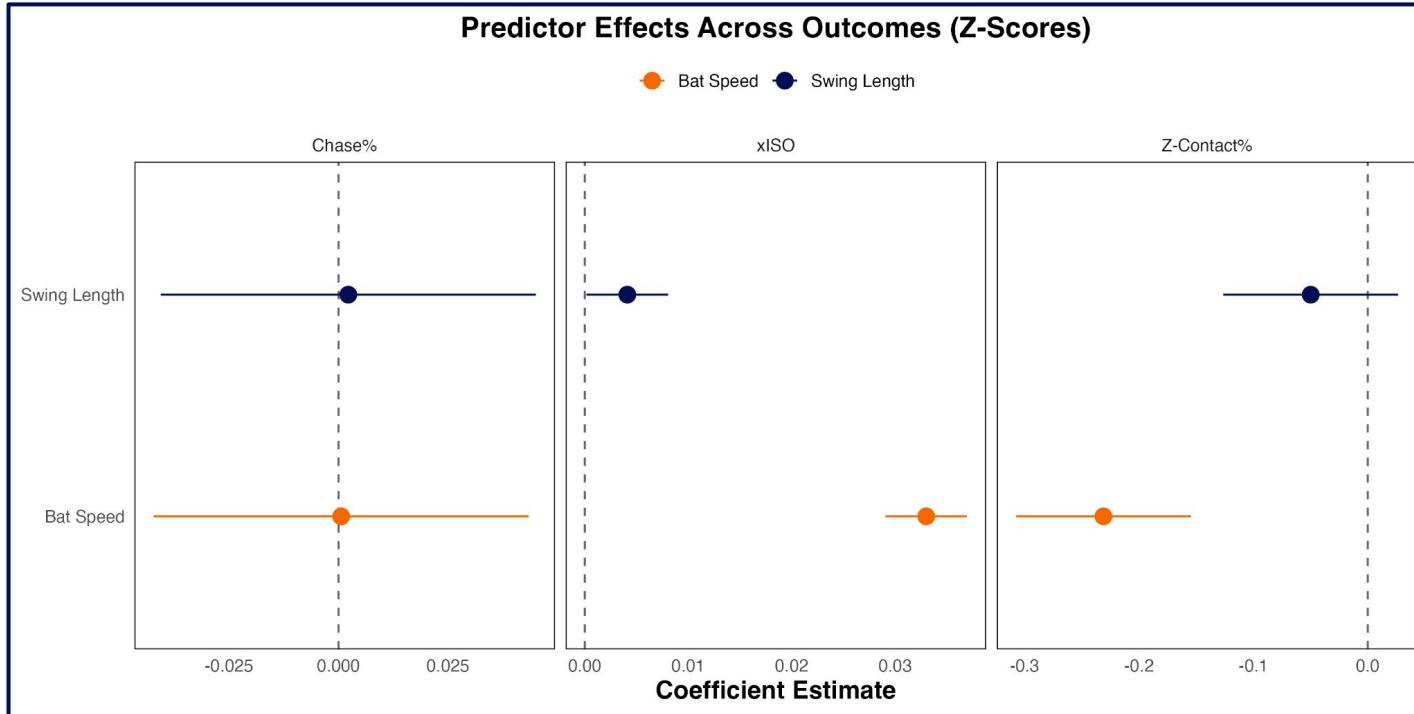
When We Change Bat Speed & Swing Length, How Does That Affect Our Model Inputs?

When We Change Bat Speed & Swing Length, How Does That Affect Our Model Inputs?

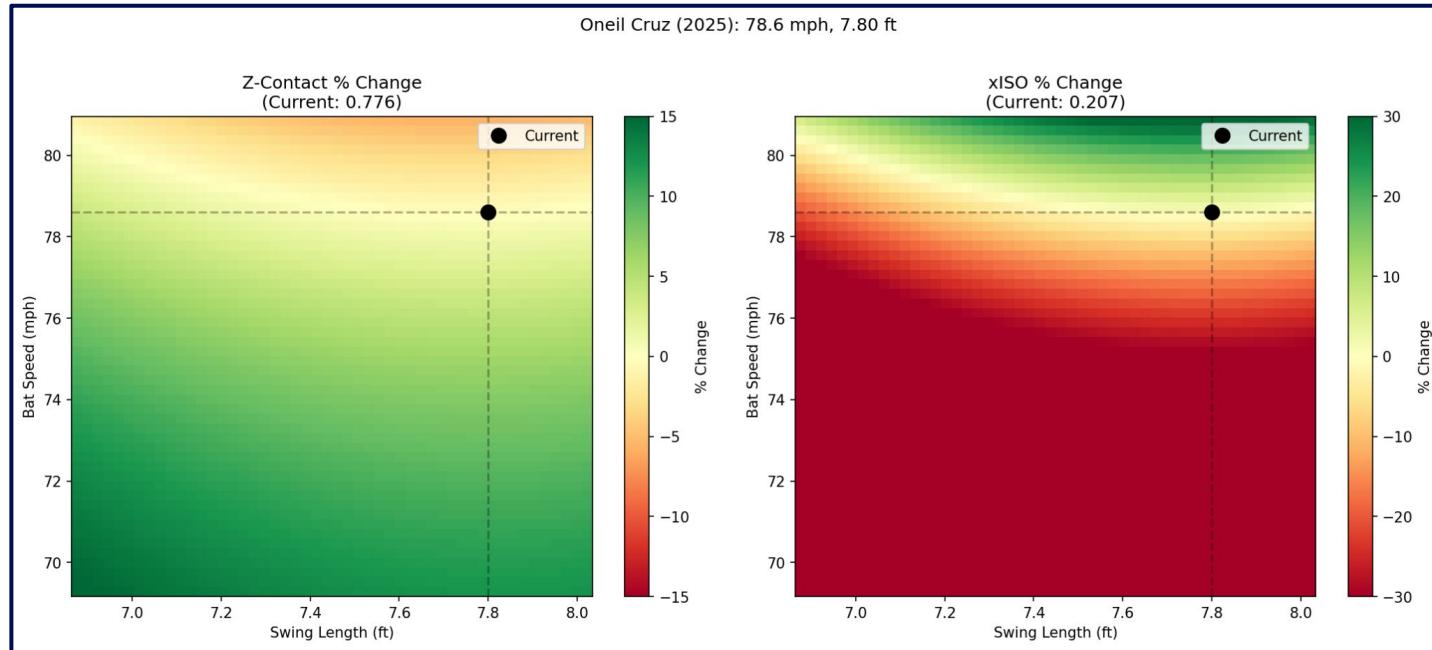
- Partial Least Squares Regression with 2 Polynomial Features
- Learns shared latent space modeling Z-Contact% and xISO **together** as a function of bat speed and swing length **together**
- Transform Z-Contact% (logit) and xISO (log) for diminishing returns at edges



Change in Bat Speed & Swing Length Effect on Model Predictors

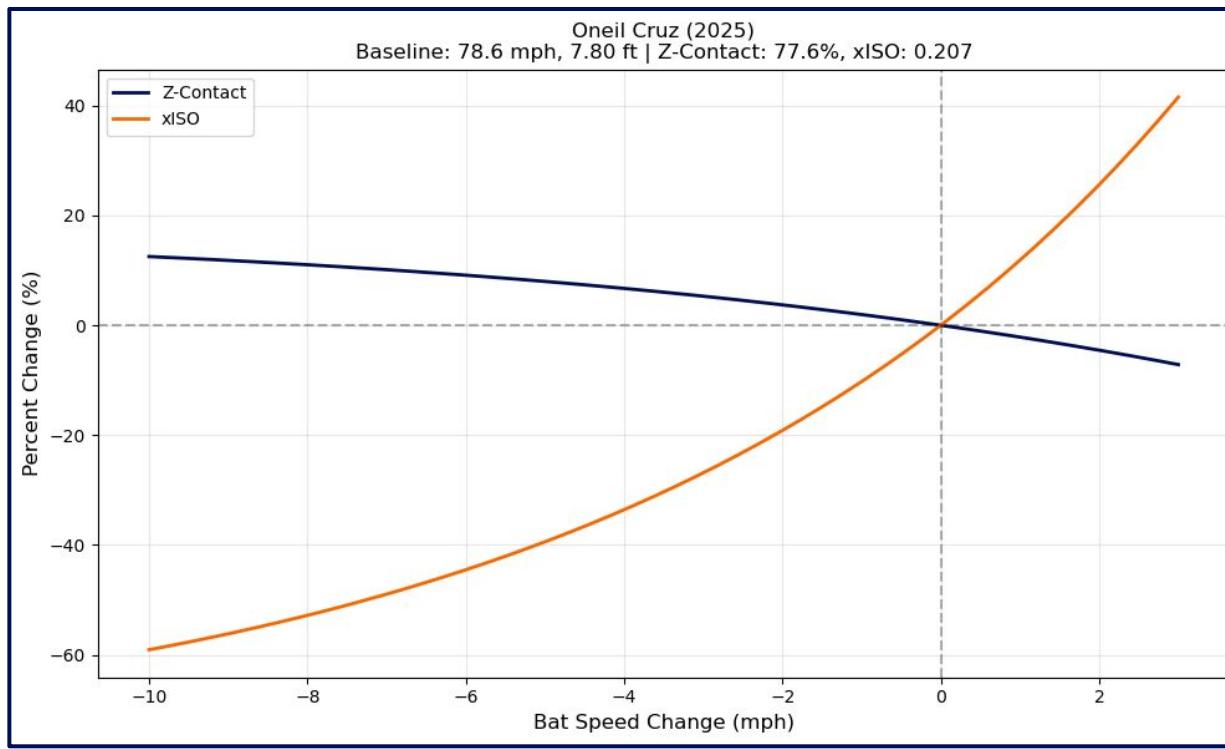


How Z-Contact% and xISO Change by Shortening Up

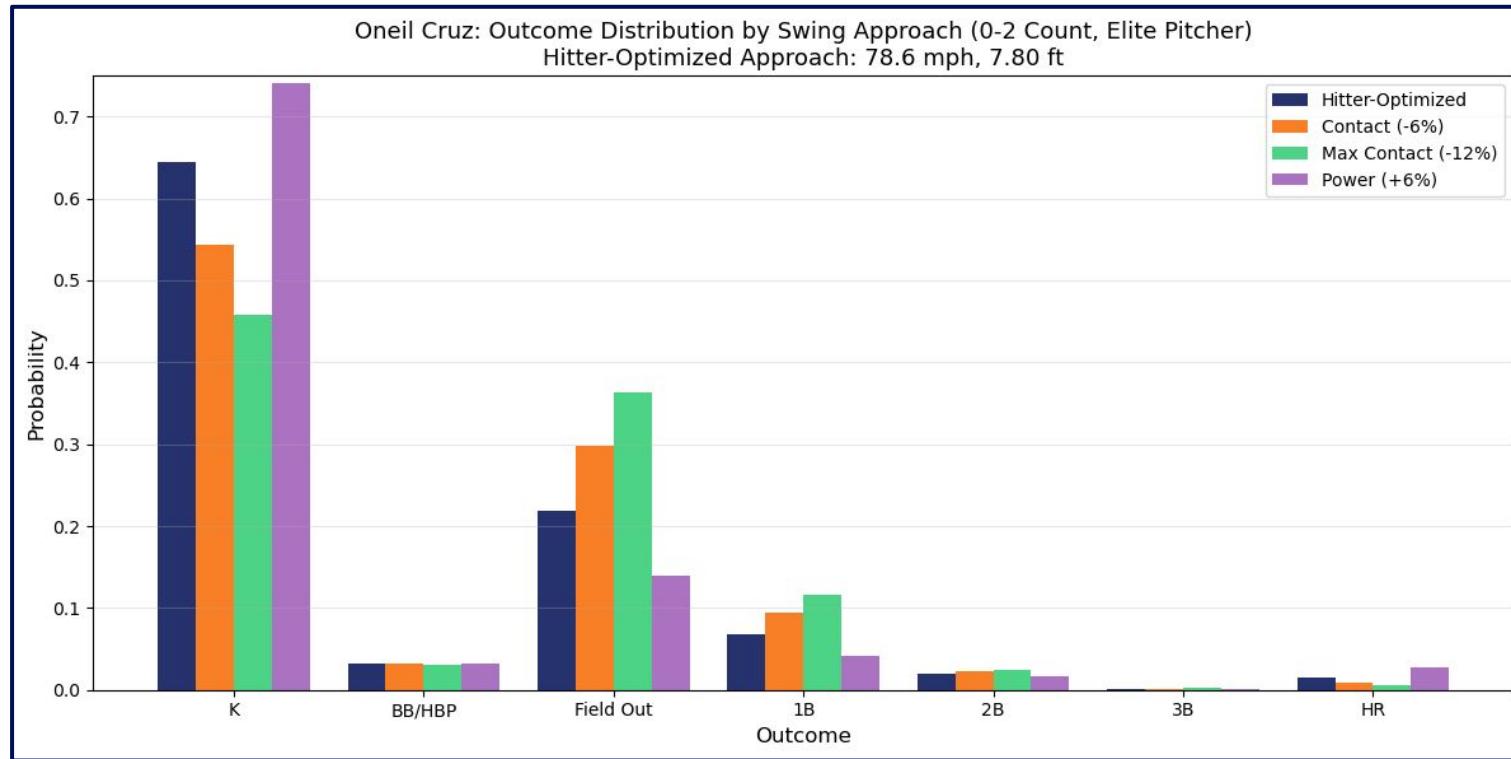


Intuitive baseball relationships hold: Longer and faster swing = **more power, less contact**

How Z-Contact% and xISO Change by Shortening Up



How Outcome Probabilities Change by Shortening Up



How Outcome Probabilities Change by Shortening Up

Bat Speed  12%

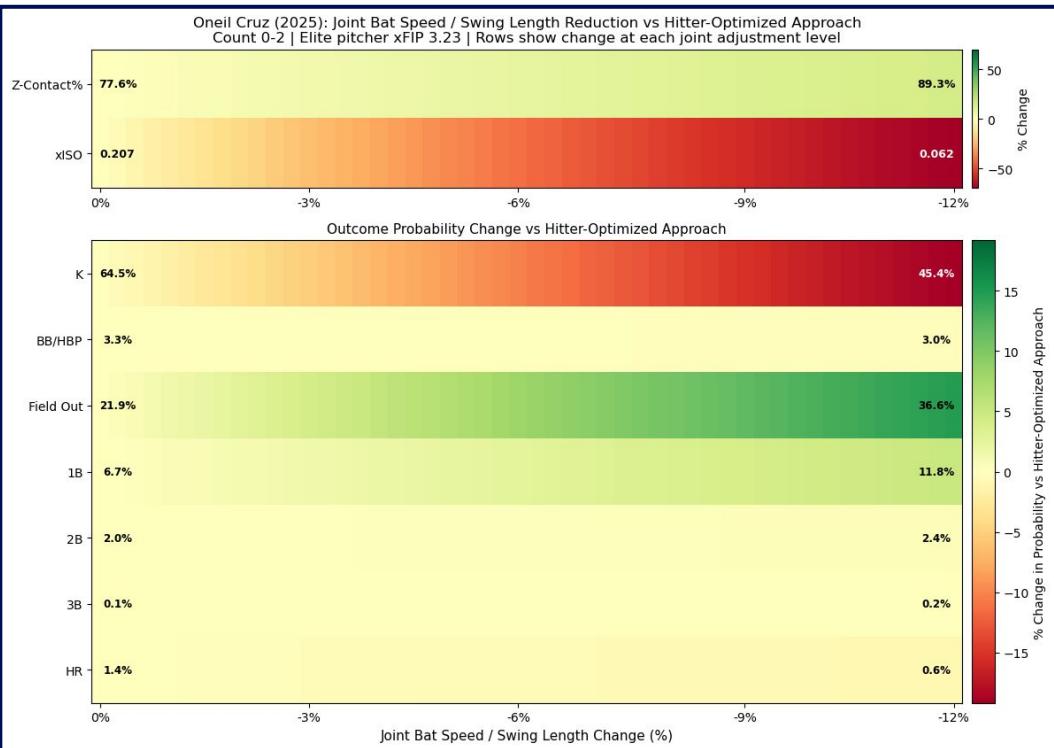
Sw Length  12%

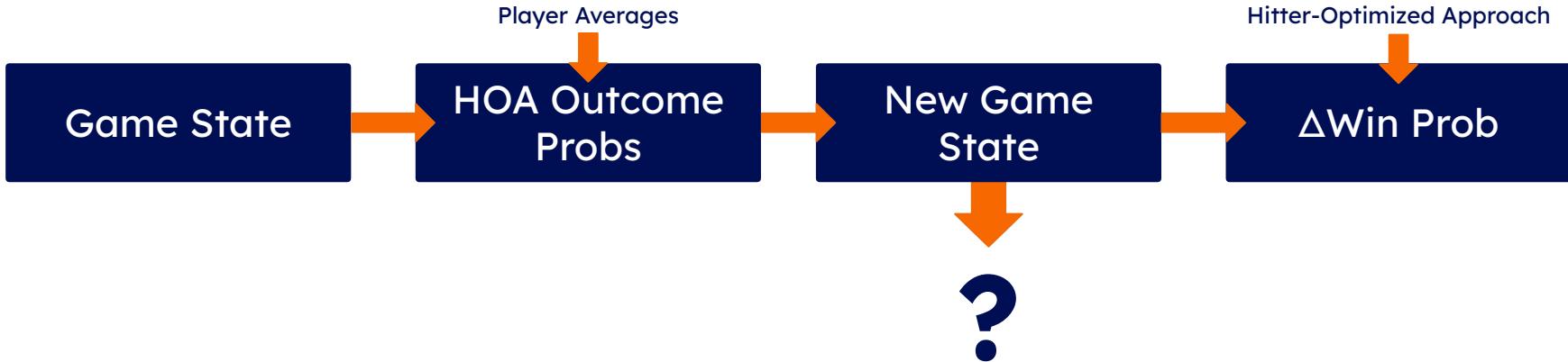
Z-Con  1.15x

xISO  0.30x

K%  0.70x

1B%  1.76x

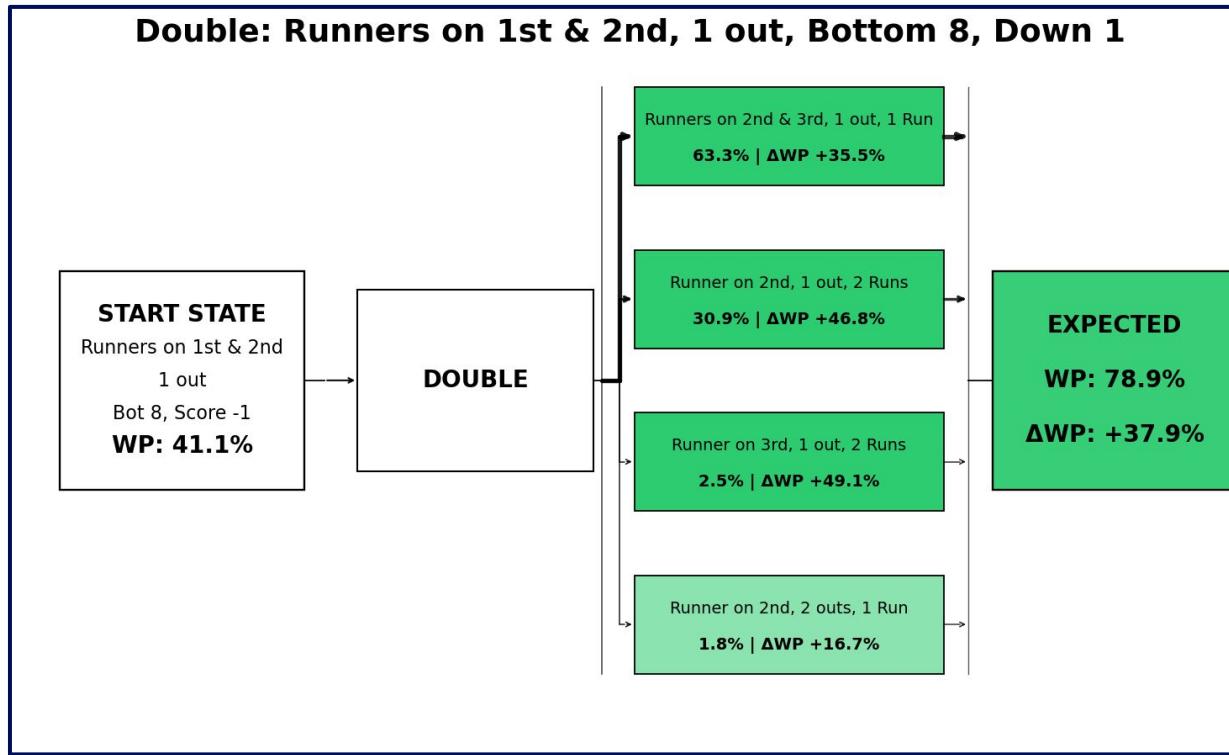




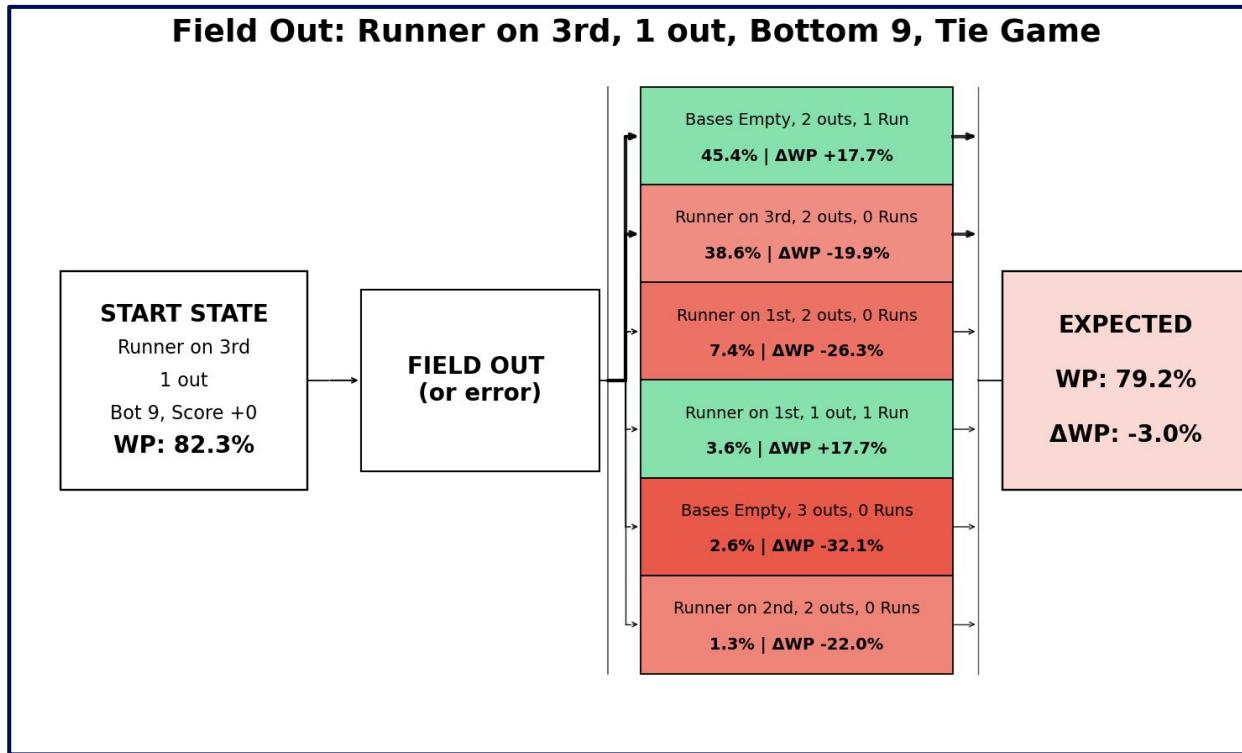
How Are We Choosing New Game States?

- For a given outcome, base state, and outs:
 - Use observed post PA base state, outs, and runs scored from 2023-2025 to form a probability distribution
 - Based on each new game state and its probability, map to an expected new win probability

Post PA Game State Transition Probabilities

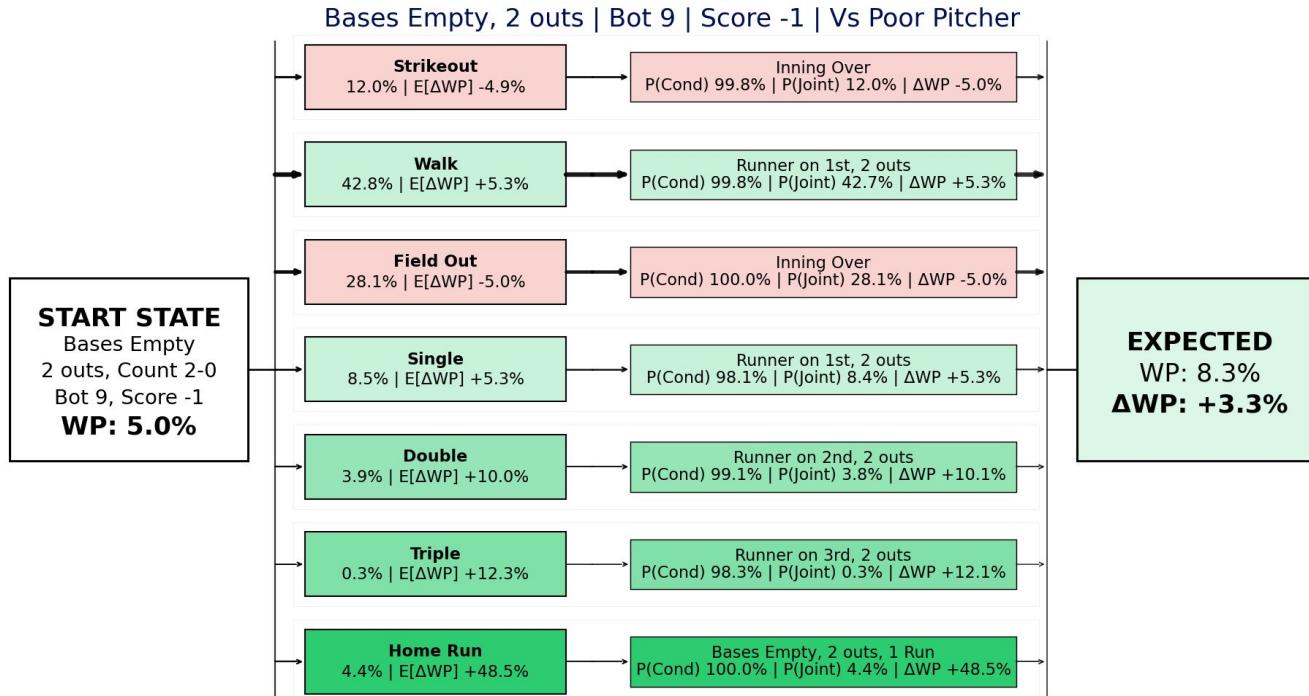


Post PA Game State Transition Probabilities



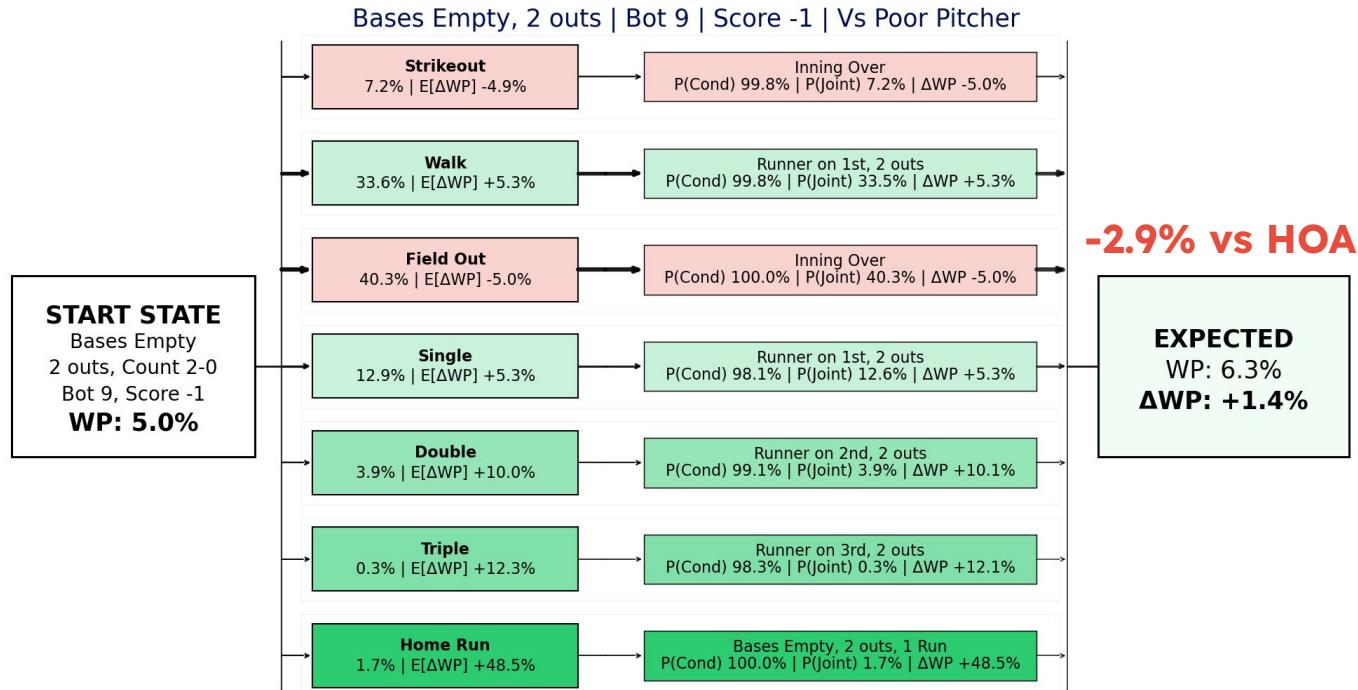
A Simple Flow Map Example

Oneil Cruz Hitter-Optimized Approach Transition Flowmap

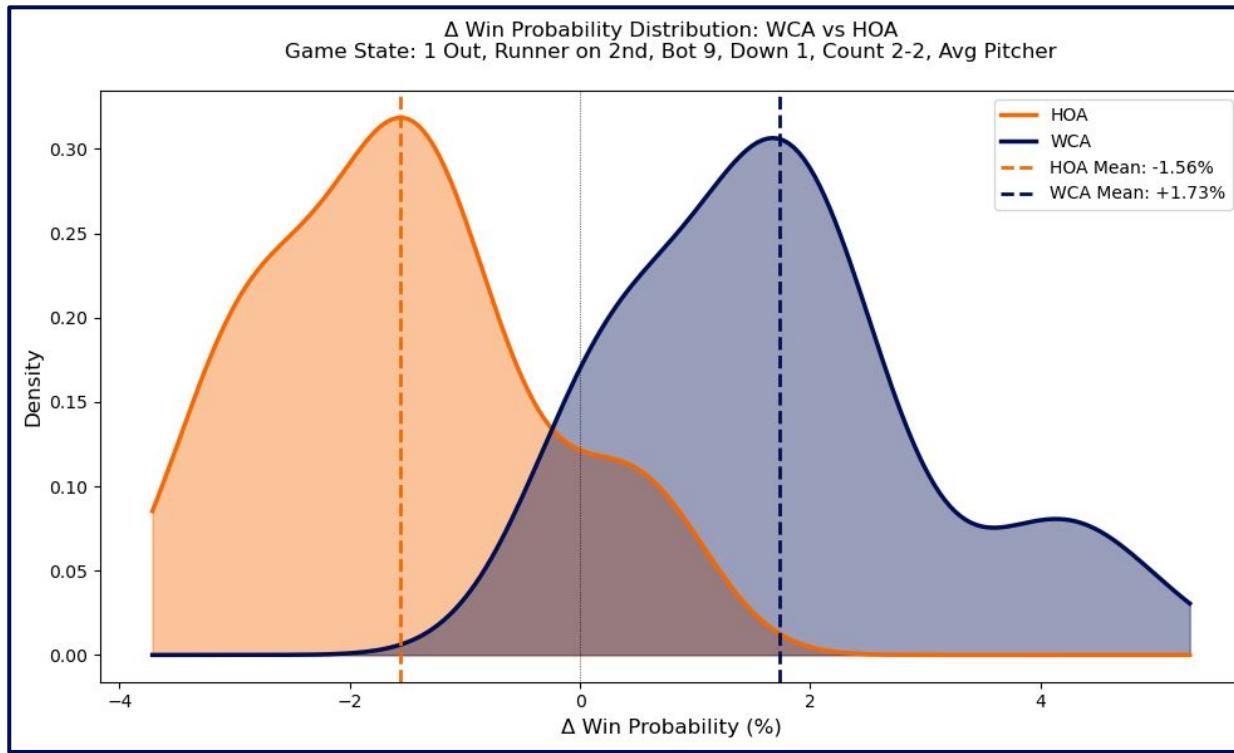


A Simple Flow Map Example

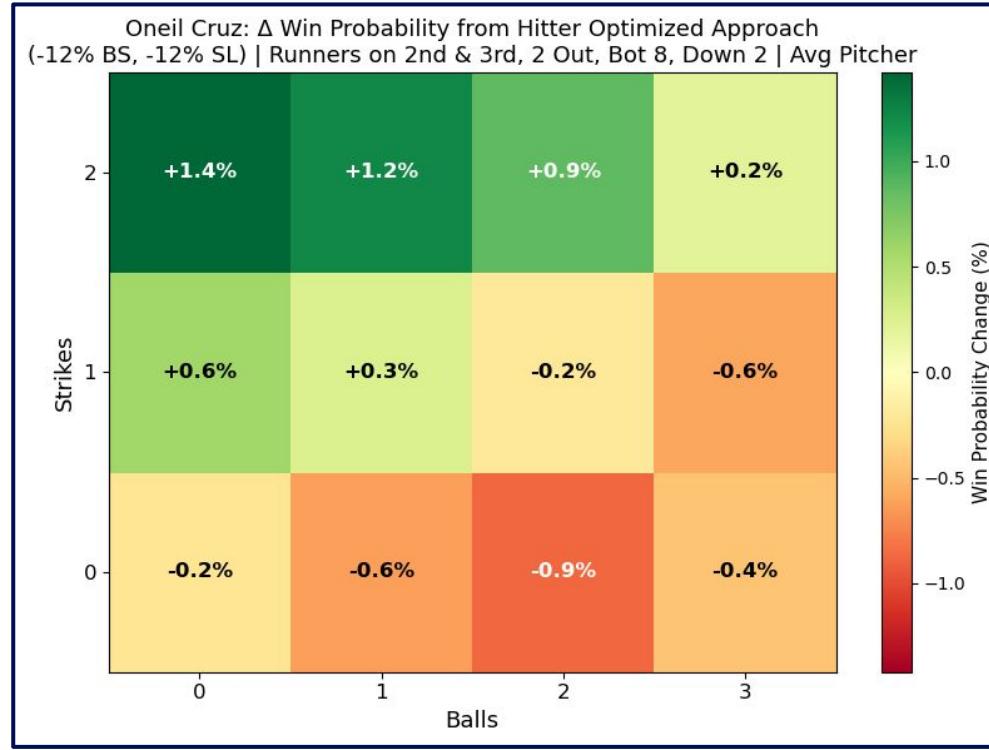
Oneil Cruz Win-Creation Approach Transition Flowmap



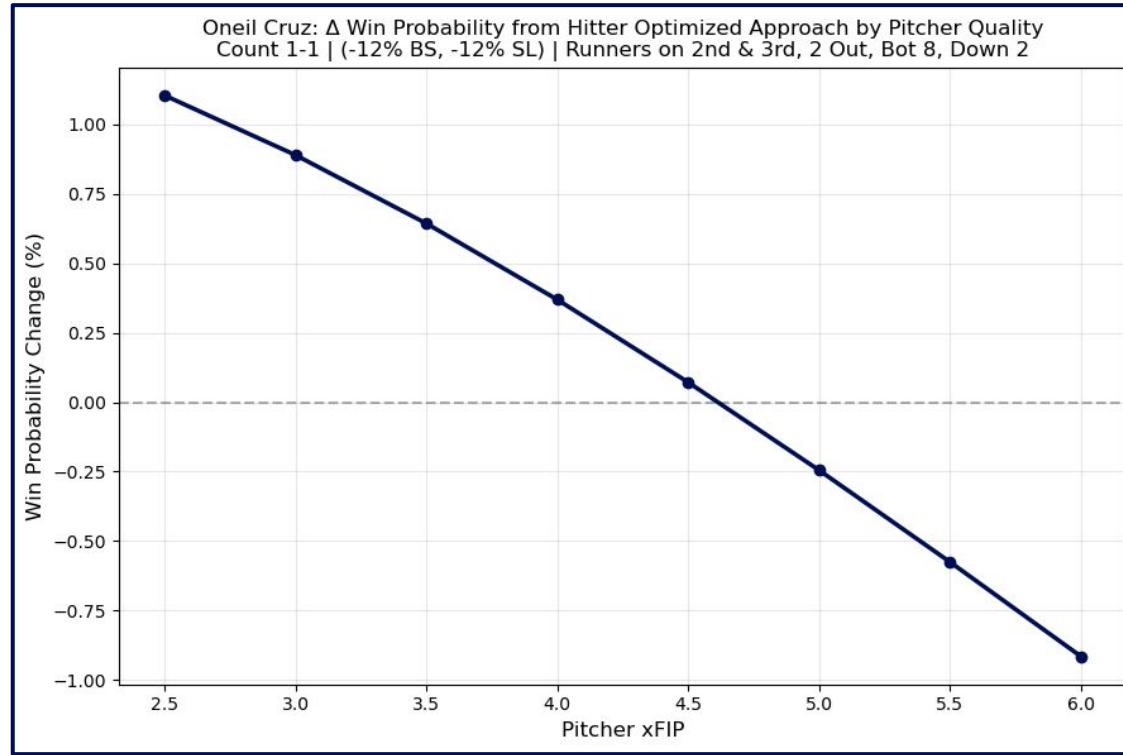
How Does the Hitter Change the Approach Recommendation?



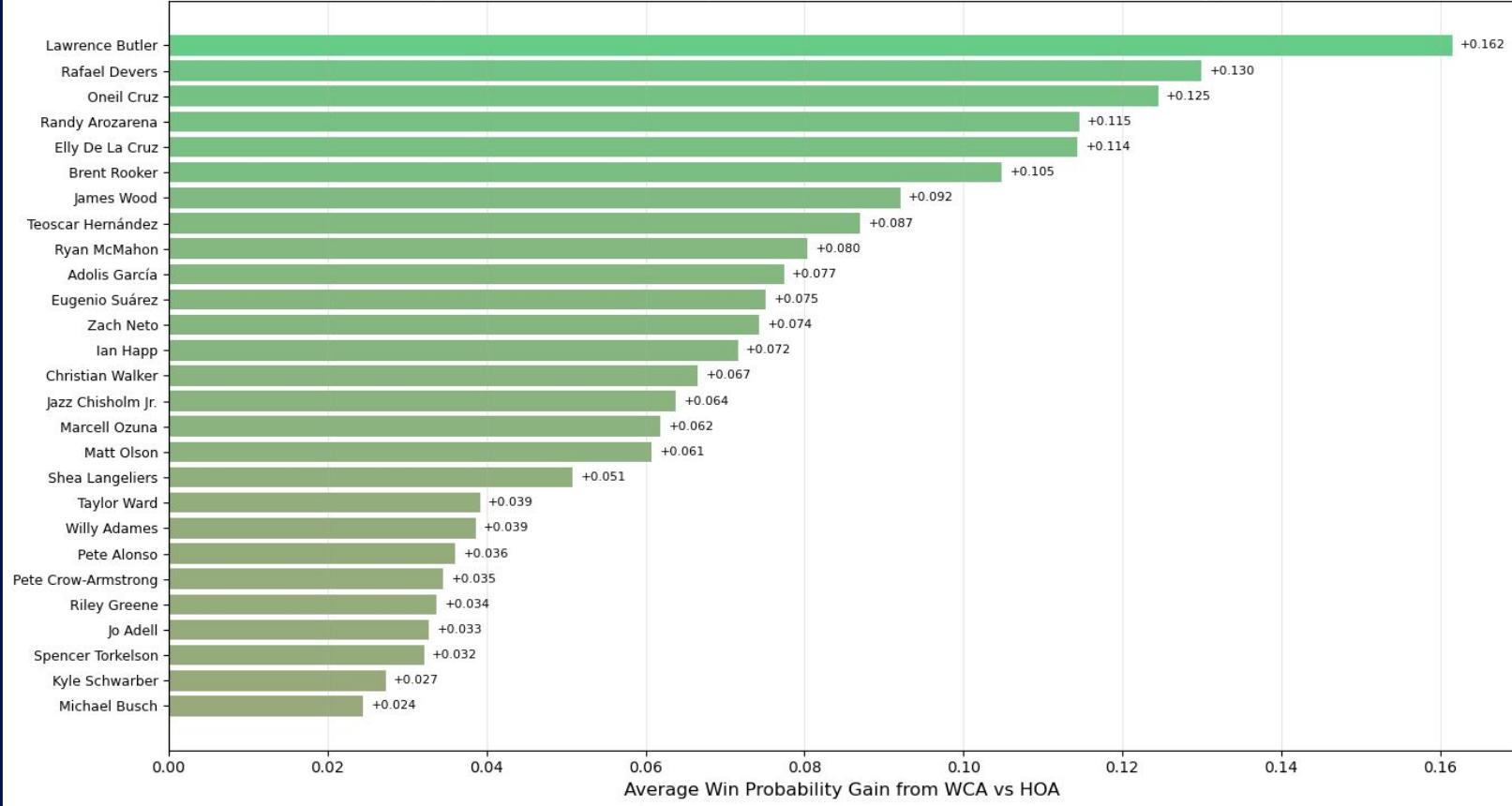
How Does the Count Change the Approach Recommendation?



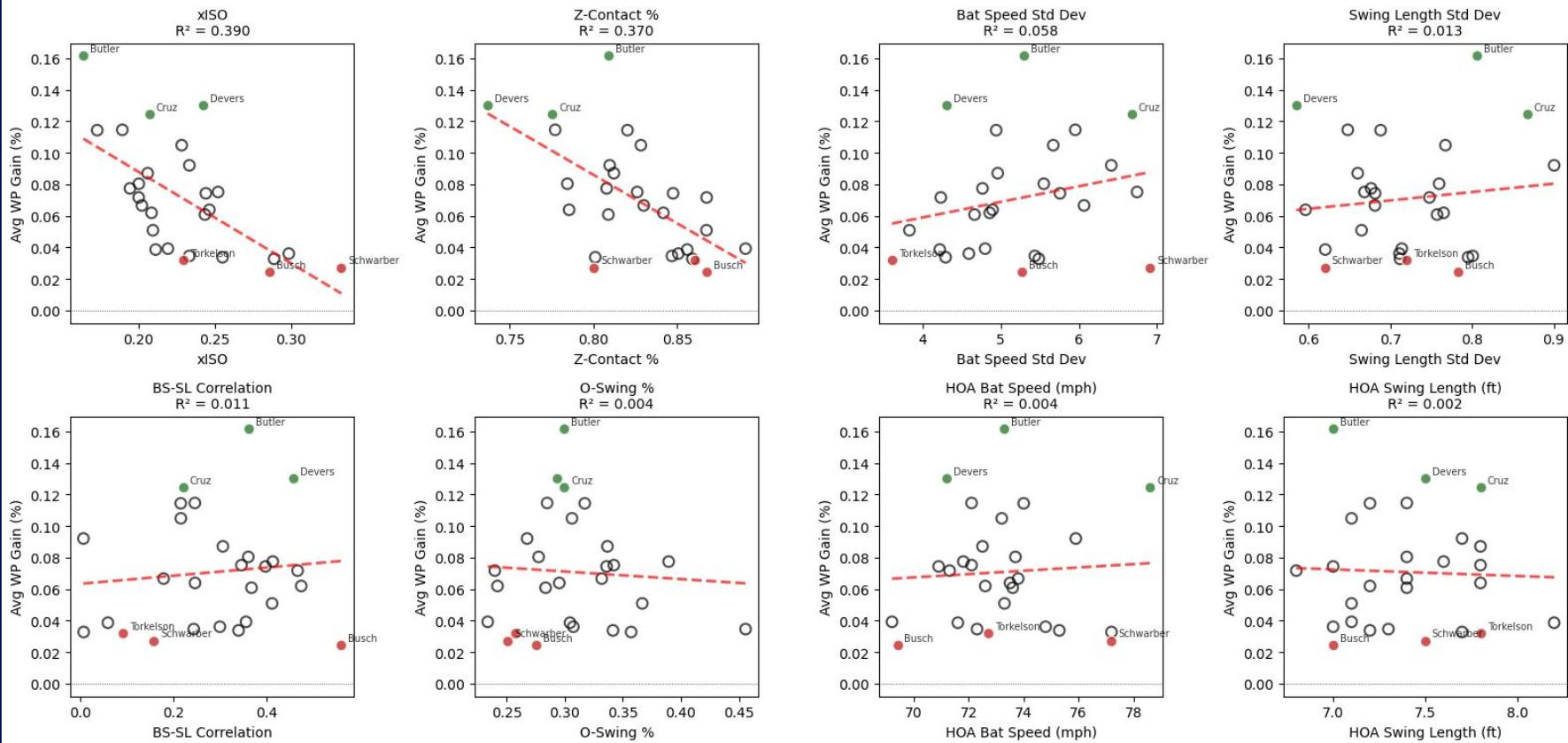
How Does the Pitcher Change the Approach Recommendation?



PVC Hitters: Who Would Benefit The Most from a Win-Creation Approach?
Using actual 2025 PA situations | WCA = best of 0%, -3%, -6%, -9%, -12% BS/SL adjustment



What Explains Win Probability Gain from WCA vs HOA? (Based on Actual 2025 PAs)



The Art of the Tradeoff

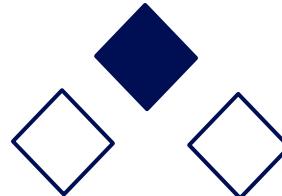
What should these hitters do in these situations?



vs.



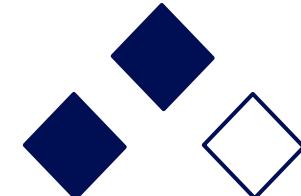
Top 9th
2 Outs
3-2 Count



vs.



Top 8th
2 Outs
3-2 Count



Who shortens up and who swings for the fences?

The Art of the Tradeoff

Difference Between Two Power-Variant Hitters...



11

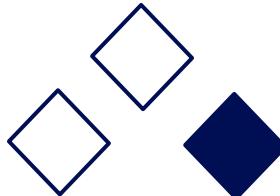
vs.



10



**Top 9th
2 Outs**



One run single
 $\Delta\text{Win Prob: } +37\%$



6

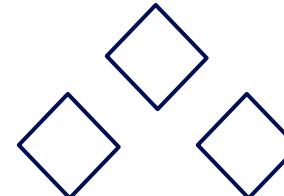
vs.



6



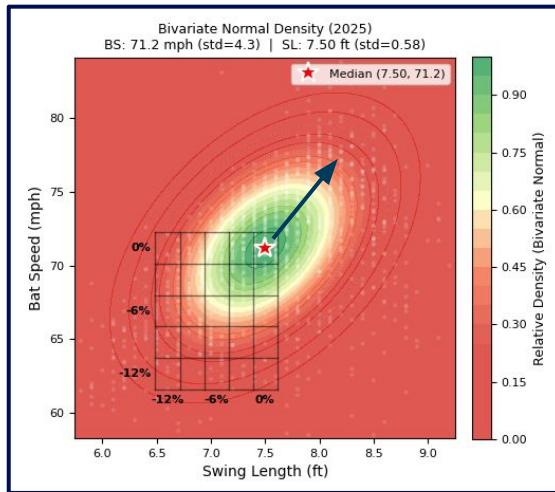
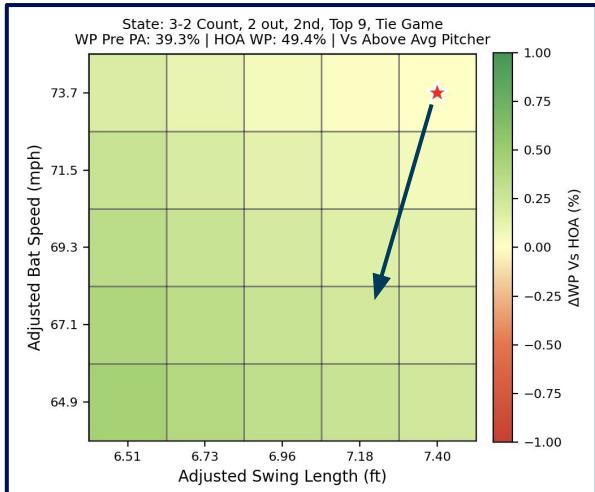
**Bot 8th
0 Outs**



Inning ending K
 $\Delta\text{Win Prob: } -11\%$

The Art of the Tradeoff

A Deeper Look



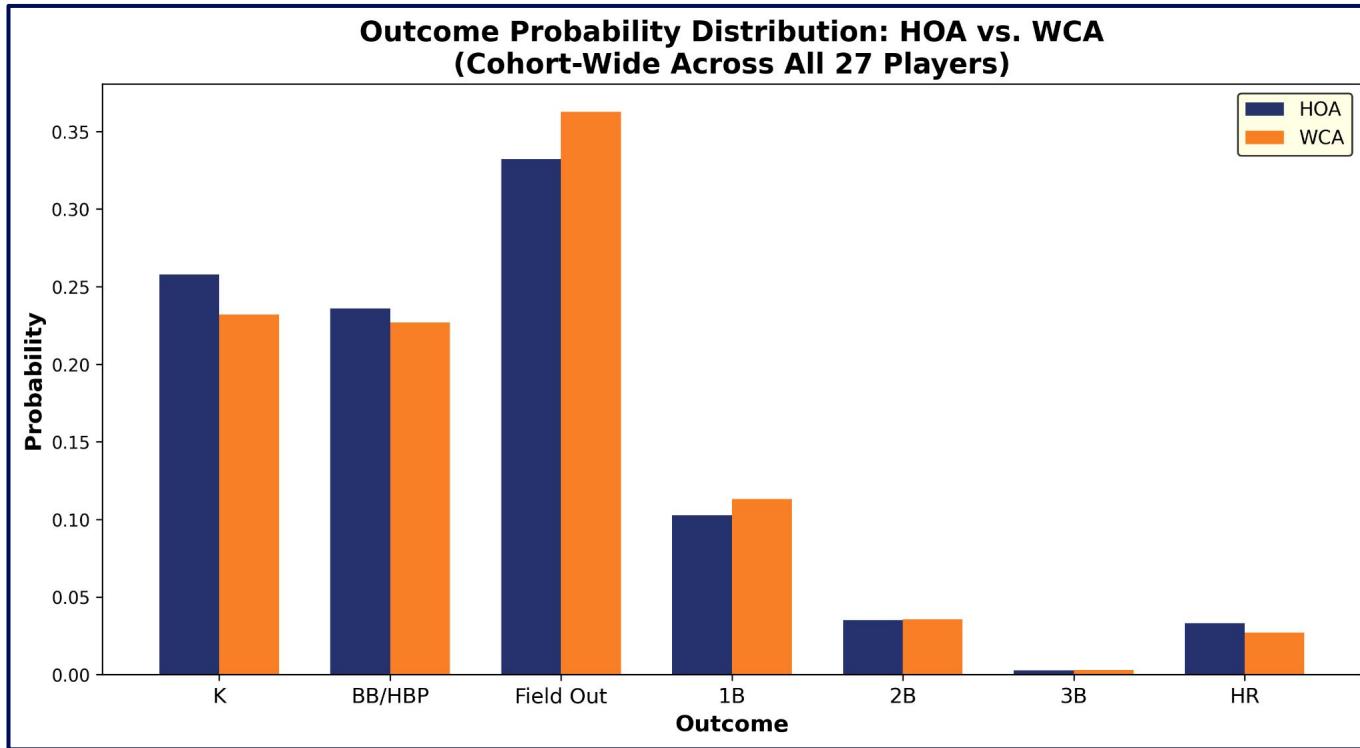
**Bat Speed: 67.9 mph
Swing Length: 7.2 ft**



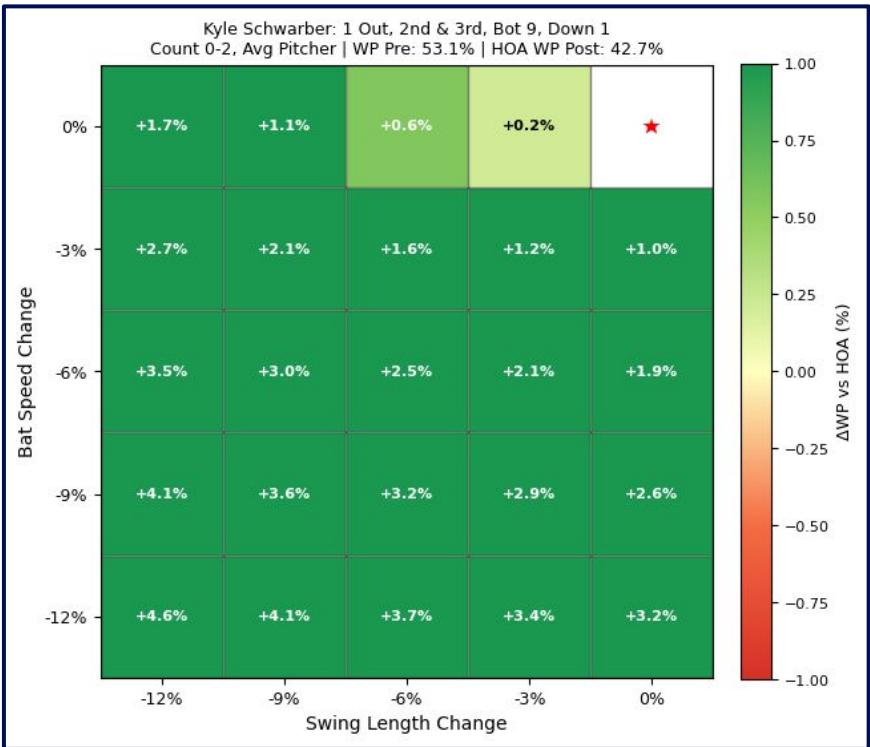
**Bat Speed: 77.1 mph
Swing Length: 8.2 ft**



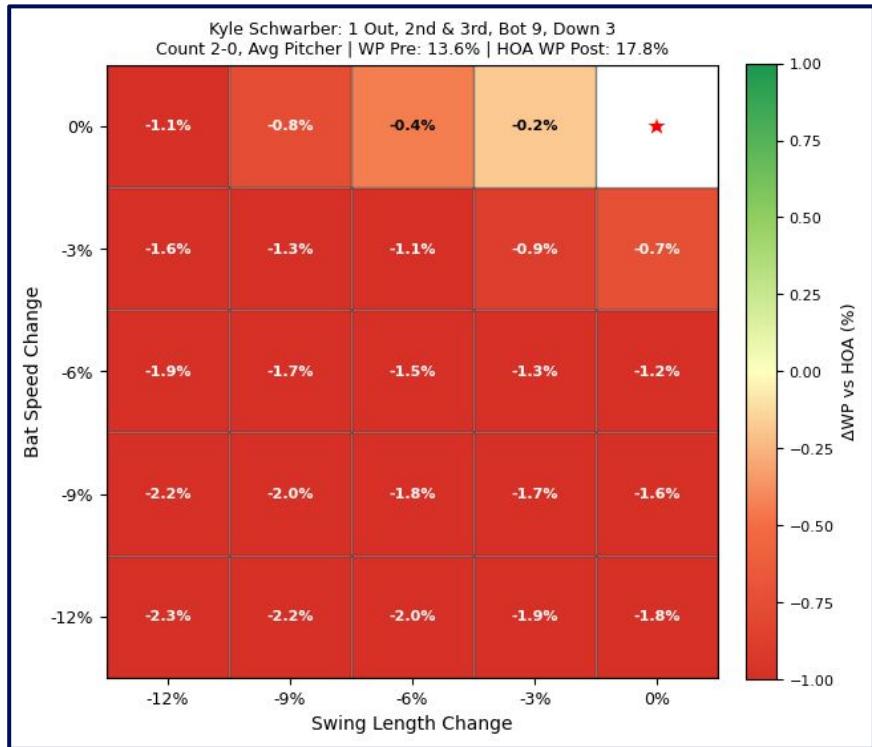
Explaining the Tradeoff



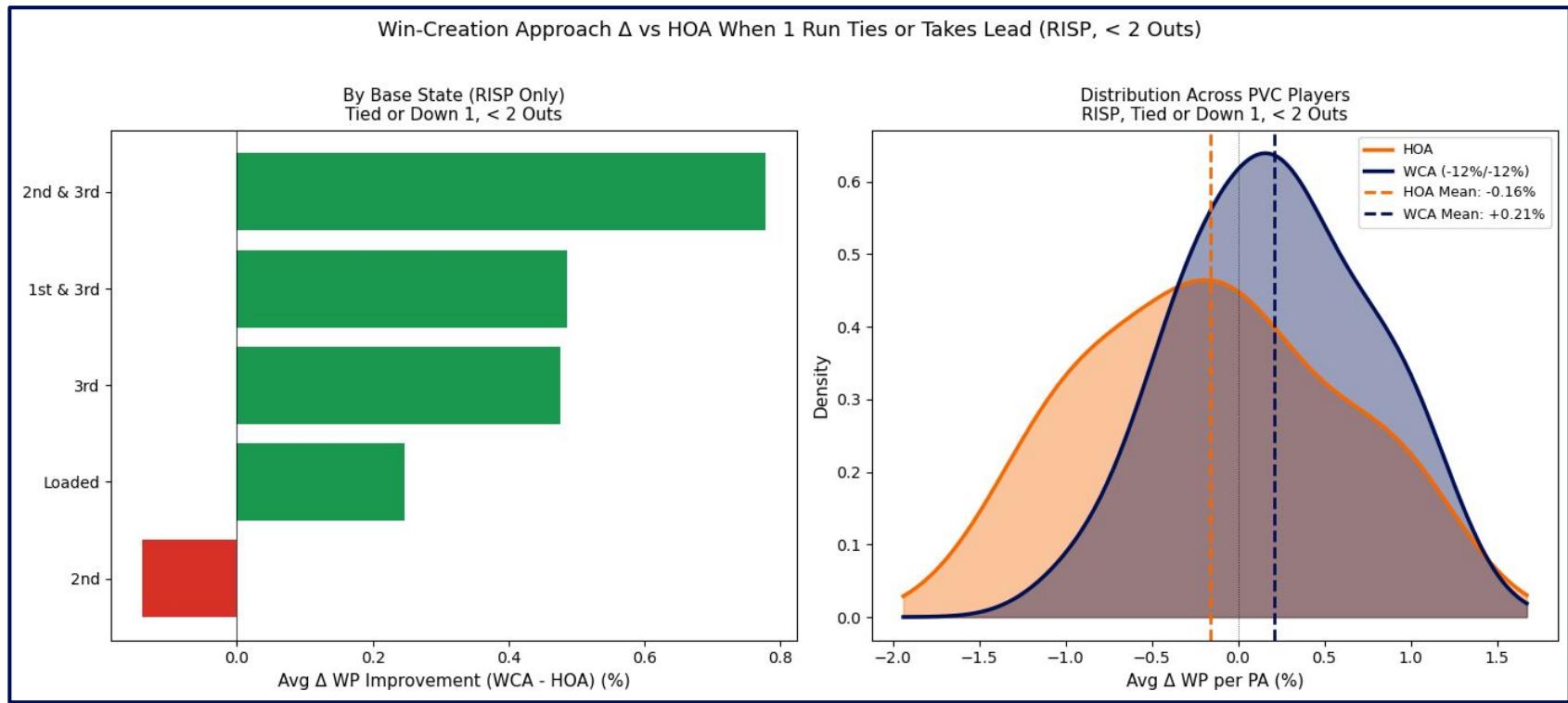
0-2, Down by 1



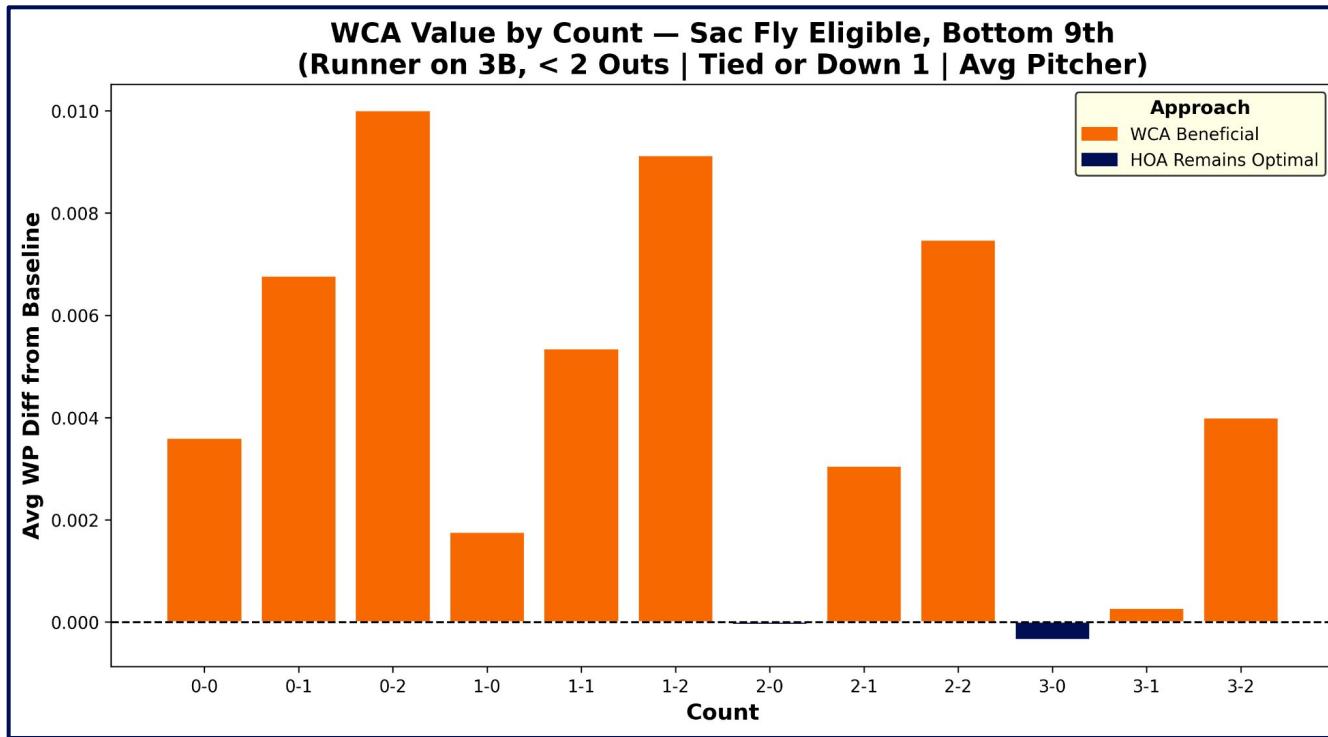
2-0, Down by 3



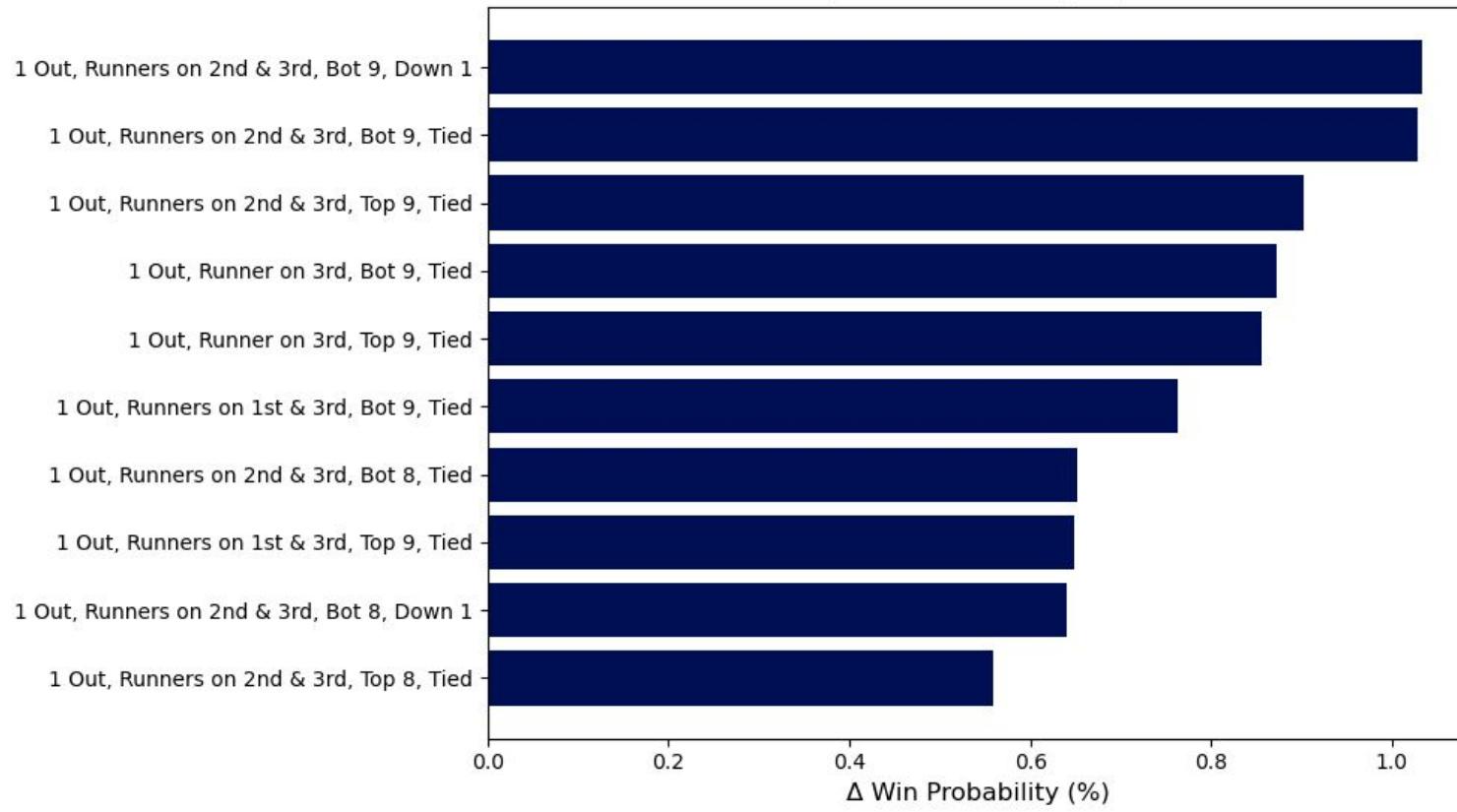
When Needing 1 Run to Tie/Lead, WCA Prevails



Sac Fly Situations by Count, Bottom 9th

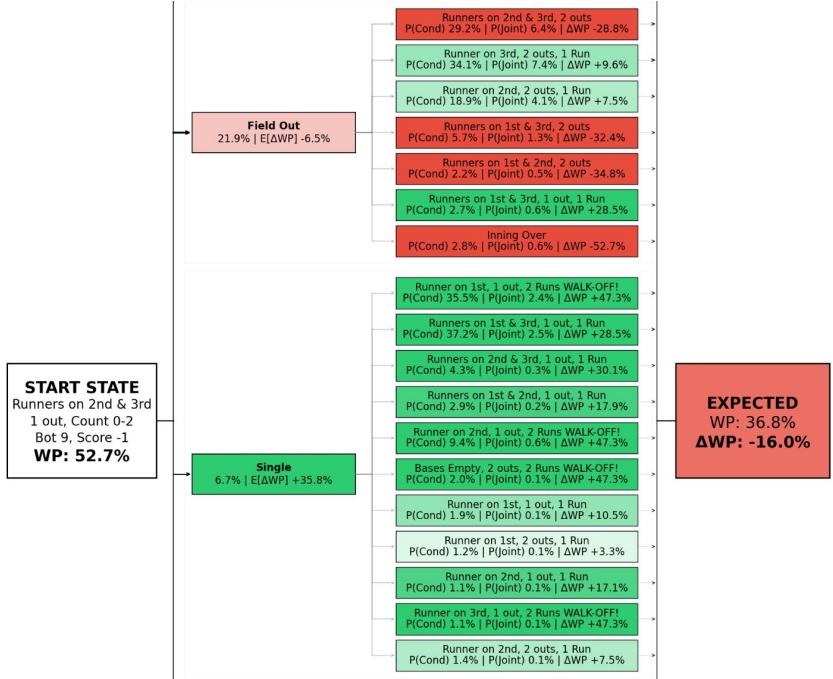


Top 10 Game States: Avg Δ Win Probability from Hitter Optimized Approach
(Across 27 PVC Players)



Remember This? Let's Take A Closer Look

Hitter-Optimized Approach (-6.2% WP)



Win-Creation Approach (+6.2% WP)



Conclusion

- Power Variance hitters experience the most to gain from a win-creation approach when a productive out can tie or take the lead late
- The WCA vs HOA recommendation often changes as the count progresses
- Players that already hit more singles but make contact less than average have more to gain from a win-creation approach

Future Improvements

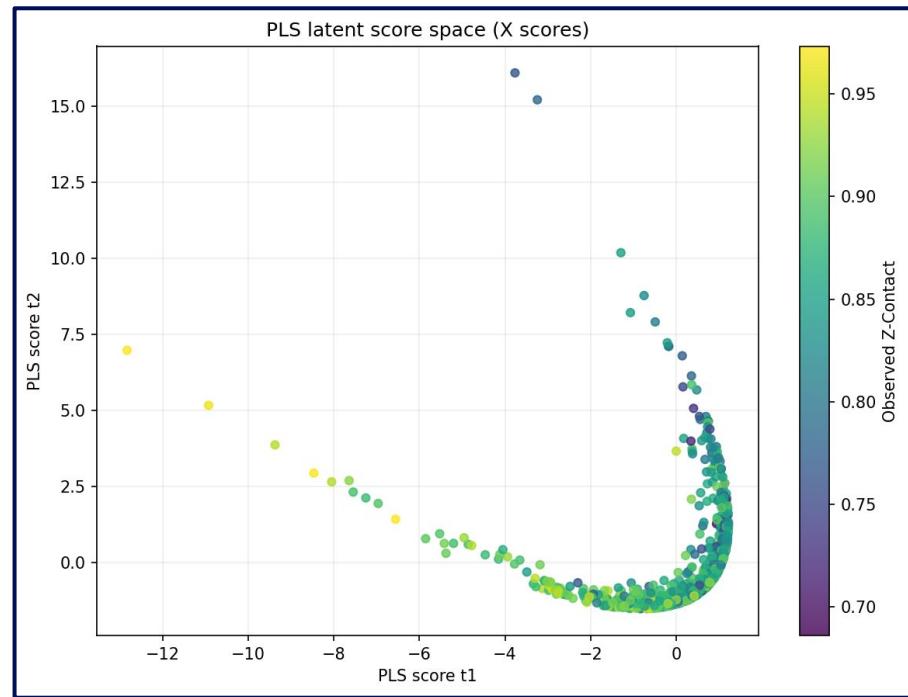
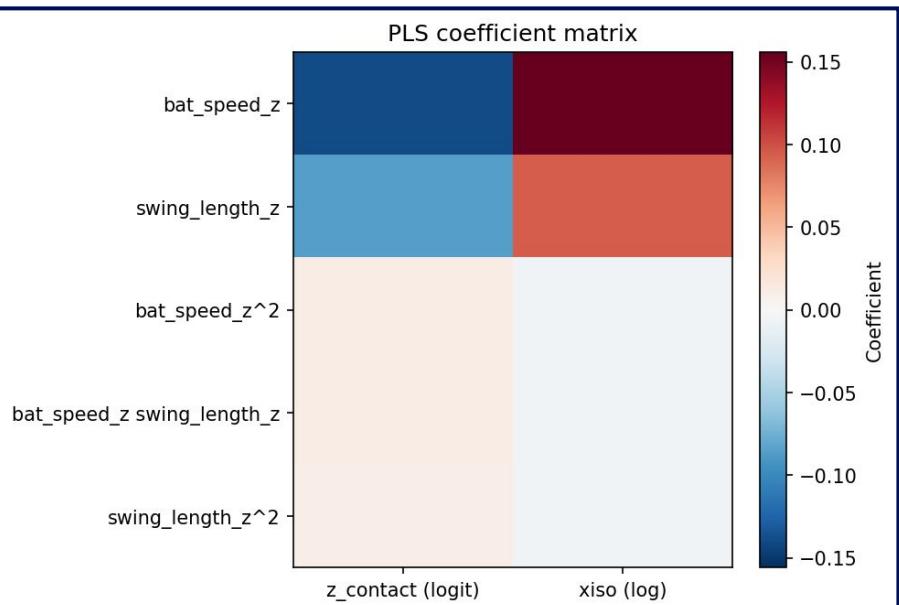
- Model outcomes with more features and add random intercepts for hitter uniqueness
- Look at more possible game states where the WCA can be beneficial
- Account for possible diminishing returns as bat speed or swing length drop too low

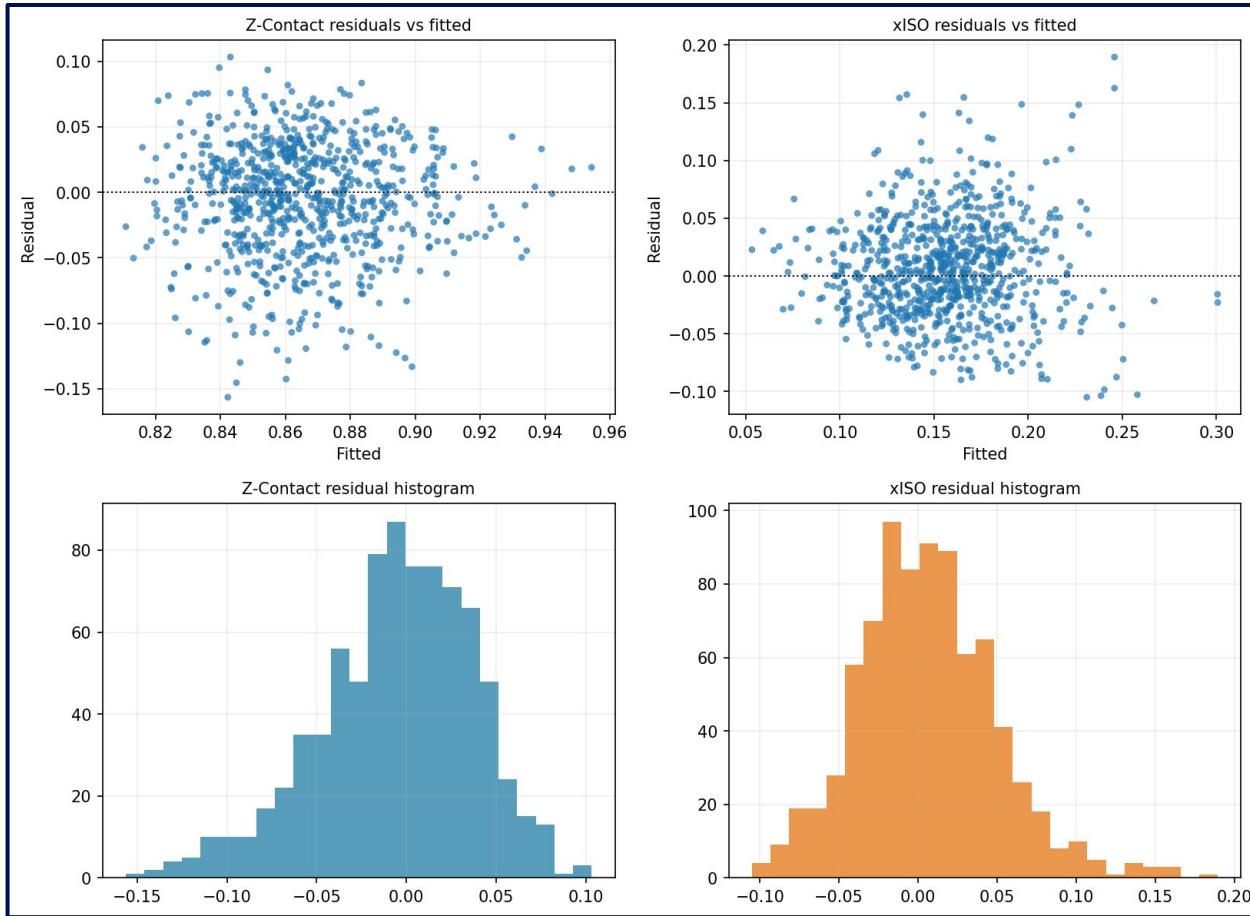
GitHub



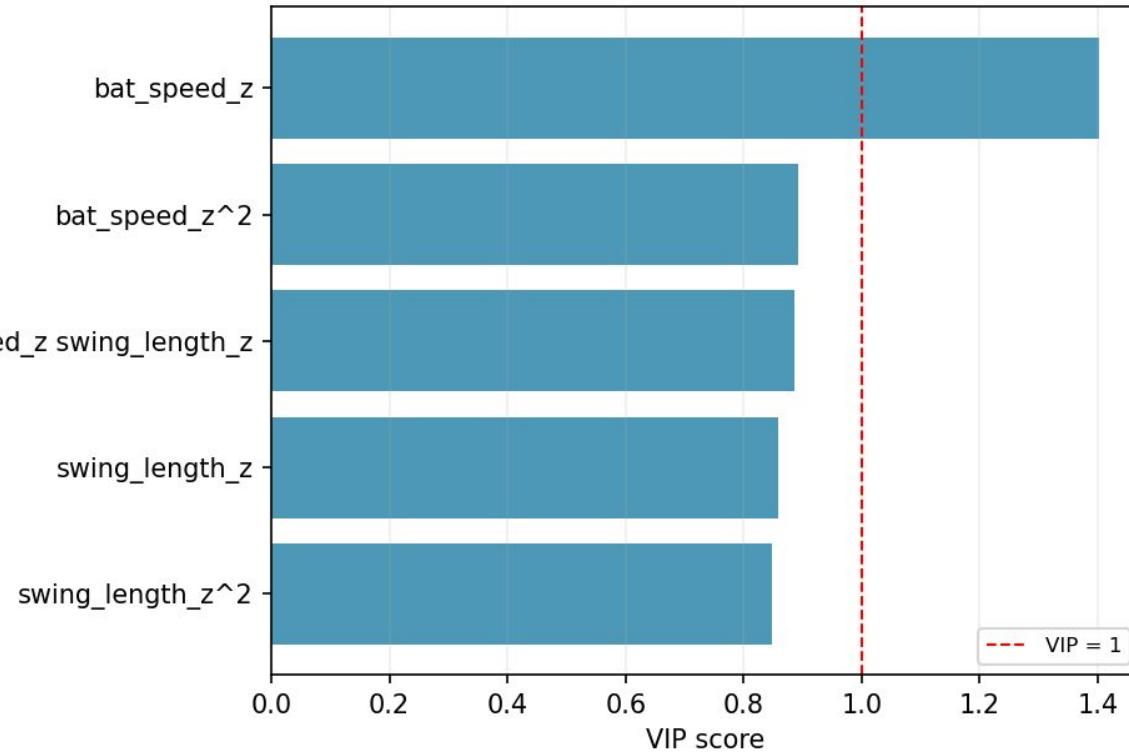
Shiny App



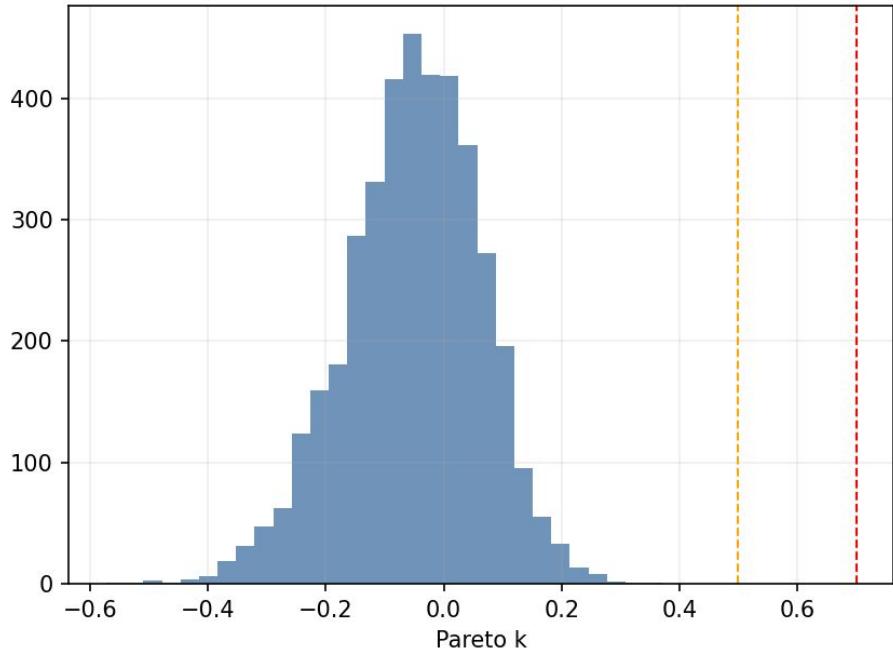




Variable Importance in Projection (VIP)



Pareto-k distribution (approx subset LOO)



Approx LOO / WAIC summary (subset)

L00 elpd: -5628.170
L00 p_loo: 1.195
WAIC elpd: -5628.159
WAIC p_waic: 1.183

