

# Swinging, Fast and Slow

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RICE UNIVERSITY  
Sport Analytics



## Conclusions (Preview)

1. Estimating batter **intention** is a helpful framework for reasoning about the sources of variation in swing metrics
2. Batters can reduce their strikeout rate by modulating their swing length according to the count ...
3. ... but it's not worth the power tradeoff for the average batter (from a linear weights perspective)

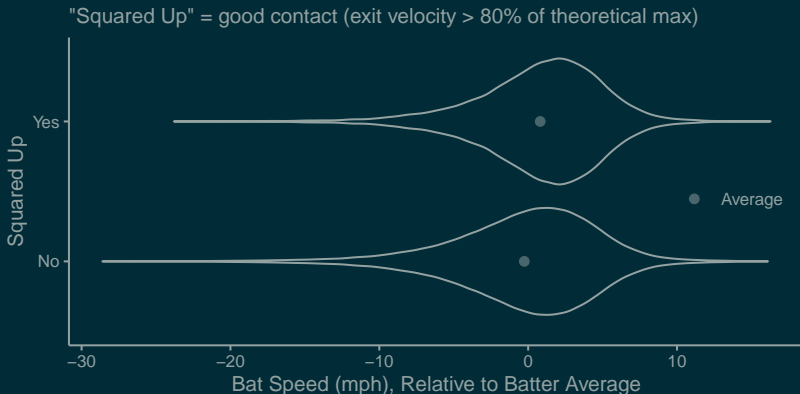
# Data

May 2024: MLB releases exciting new swing tracking metrics

- For every swing, we get:
  - Swing length (distance traveled by bat head from “start”)
  - Bat speed (speed of bat “sweet spot”)
- Measured at point of contact (or point of nearest contact)
- Additional derived metrics:
  - Squared-up rate (exit velocity  $> 80\%$  of theoretical max)
  - Fast-swing rate
  - Blasts
  - Swords
- More in the future pipeline? (miss distance, contact depth, ...)

THANK YOU, MLBAM!

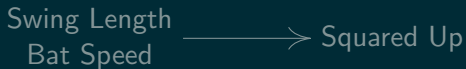
# When batters swing slower, do they make better contact?



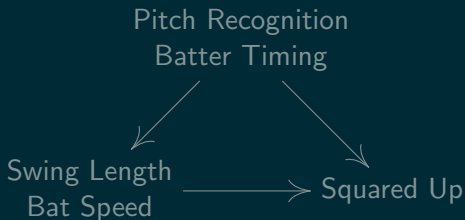
- Squared Up swings are faster on average, but ...

## Caution #1: Correlation does not imply causation

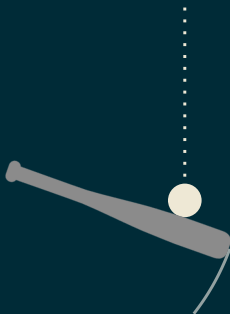
One possible causal model:



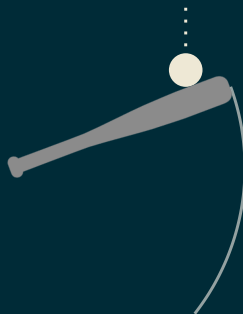
Another (more plausible) causal model with confounders:



## Caution #2: How do we get our measurement?



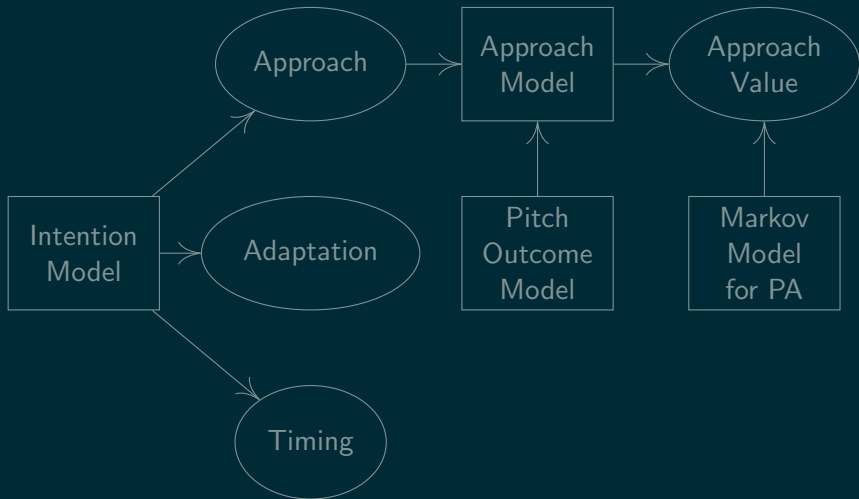
LATE Swing



EARLY Swing

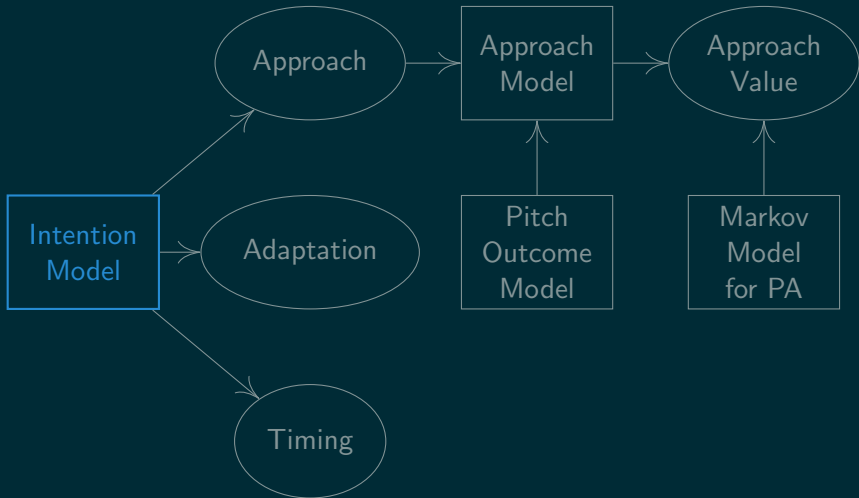
- For **identical** swings, timing determines point of measurement
- Swing length and bat speed are **outcomes**, not purely process

# Outline





# Outline



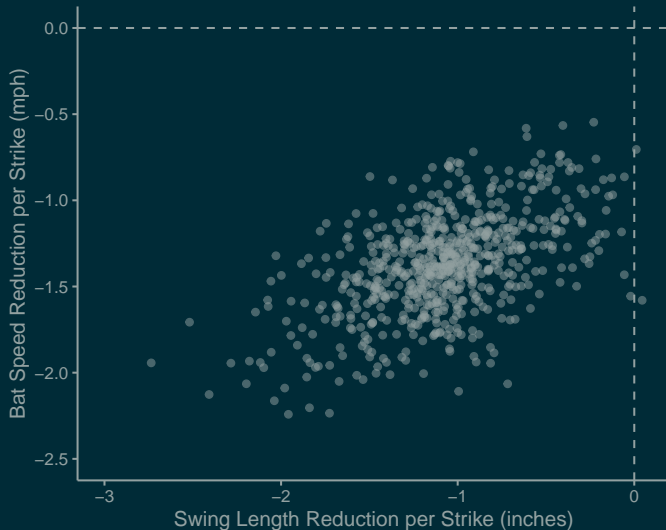
# Intention Model

Goal: Estimate swing metrics at intended point of contact

1. Filter on swings above 50 mph (avoid bunts, check-swings)
2. Filter on swings that are squared-up (avoid bad timing)
3. Fit mixed-effects linear models for swing length and bat speed
  - Fixed and random effects for intercept, count, pitch location

$$\begin{aligned}(\text{swing length})_i = & \alpha + \gamma_{b_i}^A \\ & + \beta^B \cdot (\text{balls})_i \\ & + (\beta^S + \gamma_{b_i}^S) \cdot (\text{strikes})_i \quad \left. \vphantom{\begin{aligned} & + \beta^B \cdot (\text{balls})_i \\ & + (\beta^S + \gamma_{b_i}^S) \cdot (\text{strikes})_i \end{aligned}} \right\} \text{approach} \\ & + (\beta^X + \gamma_{b_i}^X) \cdot (\text{pitch loc x})_i \\ & + (\beta^Z + \gamma_{b_i}^Z) \cdot (\text{pitch loc z})_i \quad \left. \vphantom{\begin{aligned} & + (\beta^X + \gamma_{b_i}^X) \cdot (\text{pitch loc x})_i \\ & + (\beta^Z + \gamma_{b_i}^Z) \cdot (\text{pitch loc z})_i \end{aligned}} \right\} \text{adaptation} \\ & + \epsilon_i\end{aligned}$$

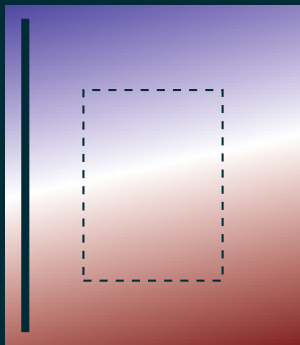
## Approach: How do intended swings vary by count?



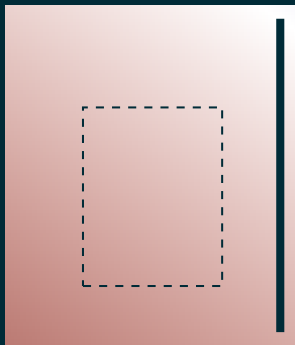
# Adaptation: How do intended swings vary by location?

Swing length predicted by intention model, assuming 0–0 count

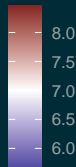
Nico Hoerner



Juan Soto

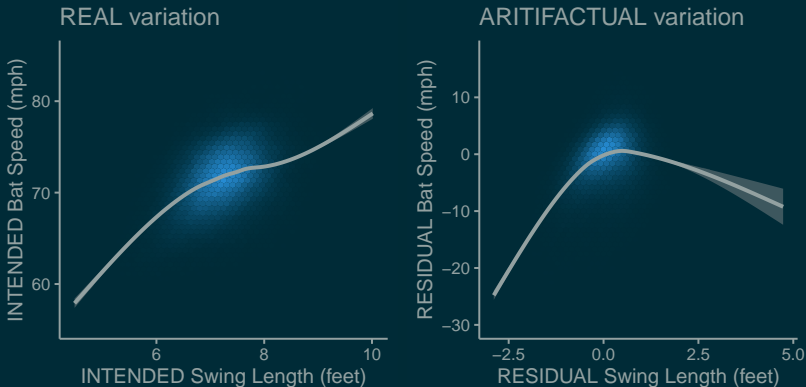


Intended  
Swing  
Length



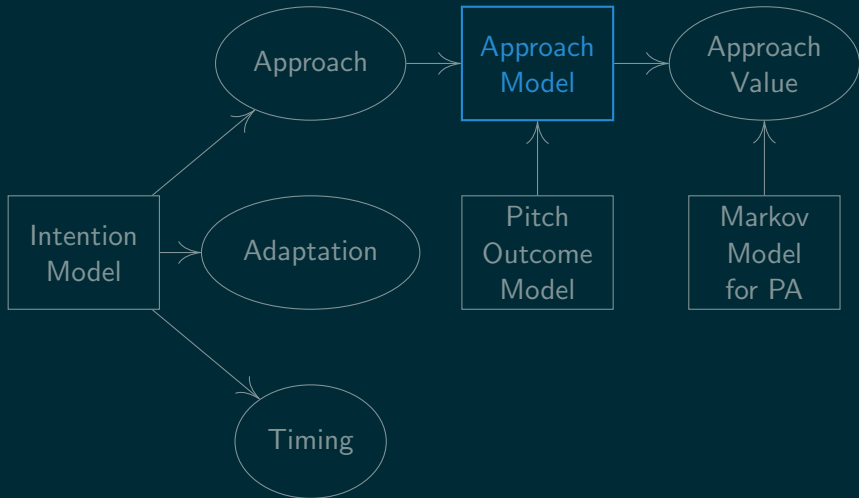
- There's clearly a difference, but it's hard to say why

## Timing: What swing variation remains unexplained?



- Left: Predicted intention for all swings (not just squared up)
- Right: Residuals (relative to intention) for all swings
  - Pattern matches bat speed through path of swing!

# Outline



## Approach Model

1. Start with pitch outcome model which estimates  $\mathbb{P}(\text{swing})$ ,  $\mathbb{P}(\text{contact} \mid \text{swing})$ ,  $\mathbb{P}(\text{fair} \mid \text{contact})$ ,  $\mathbb{E}(\text{xwOBA} \mid \text{fair})$ , etc.
  - Gradient boosting w/ 2022-2024 MLB data
2. Refit contact, fair and xwOBA models on batter approach, with previous predictions as offset

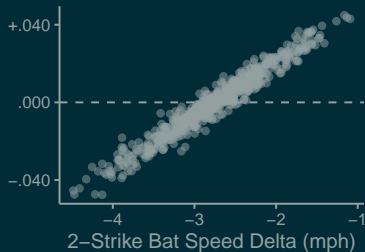
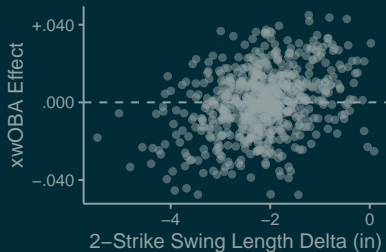
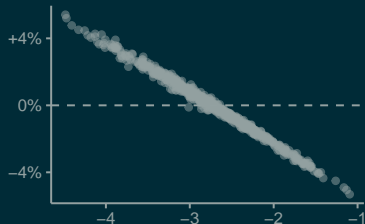
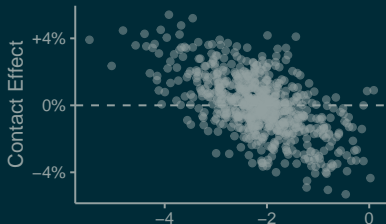
Example:  $p_i$  is contact prob,  $\hat{p}_i$  is pitch outcome model estimate

$$\log \left( \frac{p_i}{1 - p_i} \right) = \log \left( \frac{\hat{p}_i}{1 - \hat{p}_i} \right) + \beta^{SL} \cdot \hat{\gamma}_{b_i}^{SL} \cdot (\text{strikes})_i \\ + \beta^{BS} \cdot \hat{\gamma}_{b_i}^{BS} \cdot (\text{strikes})_i$$

- This is instrumental variable regression from causal inference, using count as the instrument

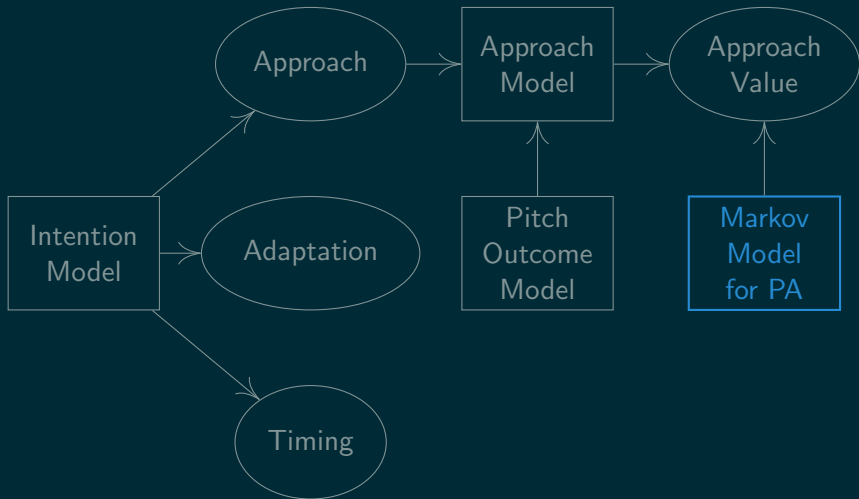
# The Effect of Approach

“Effect” is approach-aware vs. approach-agnostic prediction w/ 2 strikes

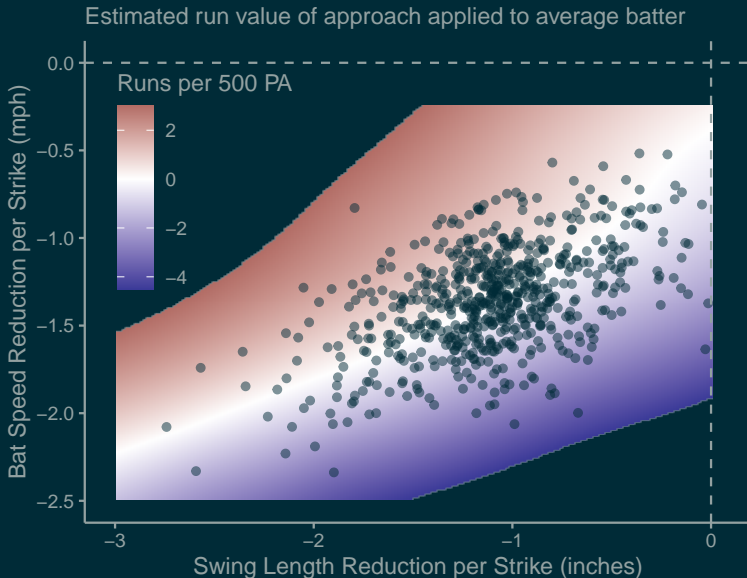




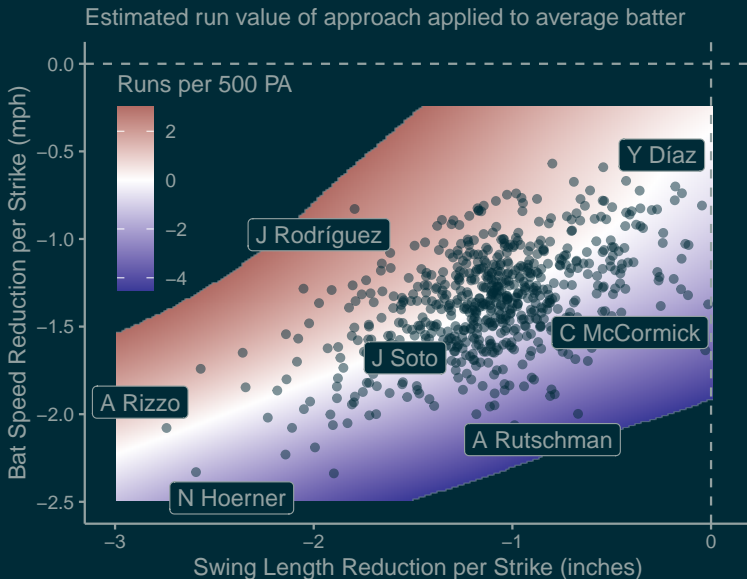
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# Is it good to modulate your swing by count?



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