A Run-Expectancy Based Approach to Stuff+

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Abstract

This project aims to quantify how "nasty" a pitcher's pitch is based on location-independent variables. Past iterations of Stuff+ models are typically based off of the attributes of the pitcher's fastball. This can lead to undervaluing changeups, which have very similar movement profiles to fastballs.

5 Highest Stuff+ Ratings by Pitch, 2023 MLB Season (Qualified Pitchers Only)
Data via FanGraphs

Fastball	Changeup	Curveball	Slider
141	111	161	171
125	108	160	144
125	102	139	142
120	100	135	136
117	99	121	133

Fig 1: The top 5 individual pitcher Stuff+ ratings on pitch types in 2023

The chart above shows the top 5 Stuff+ values for an individual qualified pitcher for each pitch type. As displayed above, the best changeups don't score nearly as well as the best fastballs, curveballs, and sliders.

Background

Assigning quantities to pitches to assess their quality has arisen as a relatively new method for pitcher evaluation. One of the most popular models is Stuff+. In most cases, a Stuff+ model is based on the physical characteristics of a pitch, such as release point, velocity, spin rate, and horizontal/vertical break. It is scaled to where a 100 Stuff+ would be an average offering. Stuff+ models are generally good predictors of how pitchers will perform. While it isn't the end-all, be-all of effective pitching, researchers found that Stuff+ in the first half of the season had a strong positive correlation with strikeout percentage in the second half. Stuff+ also had a higher correlation with second-half K%-BB%, ERA-, and FIP- than those stats in the first half did. This can show Stuff+ as a powerful predictor for future success.

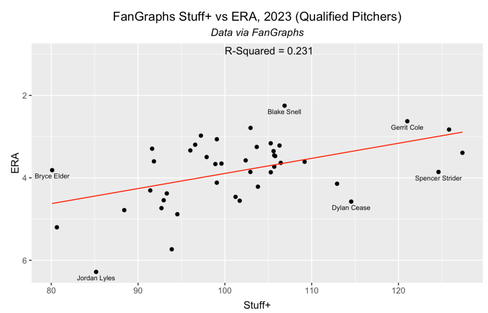

Fig 2: FanGraph's Stuff+ ratings vs pitcher ERA in 2023

One of the specific pitches I was interested in analyzing was the changeup. Changeups typically grade out poorly on Stuff+ models due to their similarities to fastballs. According to the 2023 FanGraphs leaderboard, only four qualified pitchers had a Stuff+ over 100 on their changeups: Logan Webb, Sandy Alcántara, Justin Verlander, and Charlie Morton. I believe that these numbers are not accurately capturing the quality of changeups. For this project, I opted to build a multitude of models to isolate which location-independent variables are most important in determining pitch quality, and utilized those models to create a Stuff+ metric that effectively captures pitch quality.

Data

For this project, data was collected on a pitch-by-pitch level from the 2022 and 2023 MLB seasons, as 2022 was the first season where spin axis was consistently tracked. The data was from Statcast, scraped via the baseballr package. 7 different pitches were considered: 4-seam fastballs, sinkers, cutters, sliders, curveballs, splitters, and changeups. 2-seam fastballs were classified as sinkers, sweepers were classified as sliders, and slurves were classified as curveballs. Variables considered were movement in the horizontal and vertical plane, pitch velocity, release point, and spin rate. The response variable for the models was the change in run expectancy after the pitch was thrown, where a negative value would be good for the pitcher.

Methodology

To model predicted run expectancy, Extreme Gradient Boosting (XGBoost) models were created for each pitch type. For fastballs, sinkers, and cutters, the variables used included horizontal movement, speed, vertical movement, release point, and spin. For non-fastball pitches, the difference in all categories between the pitcher's average fastball and the pitch they just threw were also considered, to determine the effect in which the off-speed pitch depends on the fastball. The predictor variable in all models was change in run expectancy.

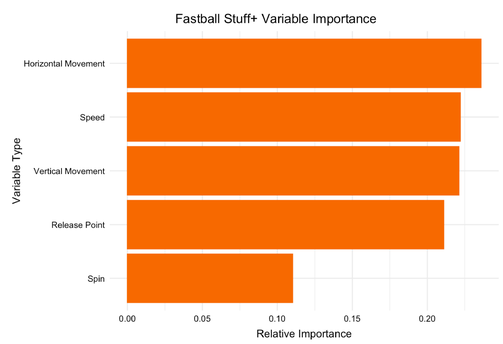

Fig 3: Variable importance plot for predicted change in run expectancy for fastballs

Hyperparameters for each model were tuned using a grid search and 5-fold cross validation. Models were trained on data from the 2022 season, and applied to data from the 2023 season. To calculate the Stuff+ number, the predicted change in run expectancy was scaled to where the median value was 100. Anything above 100 would be positive for the pitcher, while anything under 100 would indicate below-average stuff.

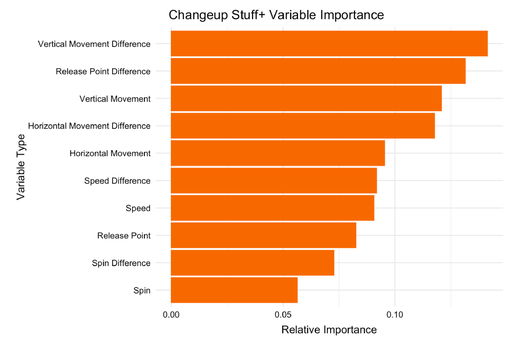

Fig 4: Variable importance plot for predicted change in run expectancy for changeups

For the changeup model, we can see where the differences between the fastball and changeup begin to play a part. Vertical movement, release point, and horizontal movement were all important variables.

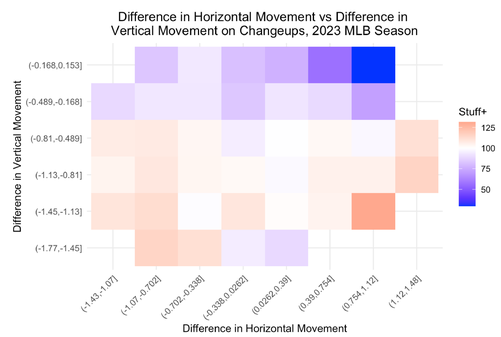

Fig 5: Horizontal Movement vs Vertical Movement differences on changeups for the 2023 MLB season, colored by average Stuff+

This graph displays the average Stuff+ in each bucket, where each bucket is comprised of a certain range of the difference in horizontal and vertical movement. Pitches with lower differences in horizontal and vertical movement received lower Stuff+ grades, while pitches with higher differences received higher Stuff+ grades. We can see that the model accounts for both lefties and righties, as high movement in either direction is correlated with higher Stuff+ grades. Many pitchers known for high velocity grade out well on this model, including Grayson Rodriguez, Edward Cabrera, Shane McClanahan, Sandy Alcántara, and Brayan Bello. However, other pitchers that are not necessarily known for high velocity but still throw effective changeups also have higher Stuff+ grades, those pitchers include Trevor Richards, Merrill Kelly, Steven Matz, and Michael Wacha.

Starting Pitcher Stuff+ Leaders in 2023 (Min. 1500 Pitches)

	Pitcher	Stuff+		Pitcher	Stuff+
1	Shane McClanahan	125	9	Sandy Alcántara	115
2	Spencer Strider	123	10	Ranger Suárez	115
3	Edward Cabrera	119	11	Mike King	114
4	Kutter Crawford	118	12	MacKenzie Gore	114
5	Brandon Pfaadt	117	13	Zac Gallen	114
6	Zack Wheeler	116	14	Gerrit Cole	113
7	Luis Castillo	116	15	Nick Martínez	113
8	Grayson Rodriguez	115	16	Max Scherzer	113

Fig 6: Stuff+ Leaders, Starting Pitchers, 2023 MLB Season

Conclusion

By creating separate models for each pitch, we are able to isolate variables that may have a higher effect on run expectancy for one pitch as opposed to another. In addition to what is displayed about fastballs and changeups, there are also other interesting trends for other pitches. The most important variable for cutters was horizontal movement, and spin rate was significantly more impactful in the cutter model than other pitches. Changeups were most dependent on differences from the fastball rather than raw values compared to other pitches. Vertical movement was one of the most impactful variables for the splitter model, and for sliders, it was horizontal movement that had a significant impact on predicted values. For the curveball, the raw values carried much more importance than the differences between the fastball, suggesting that curveballs are less dependent on the pitcher's fastball to be deceptive.

Future Improvements

For future research, having access to a larger dataset will help to improve predictive power of the models. Additionally, model performance can be improved through further tuning of hyperparameters, in order to improve the accuracy of each individual pitch model. Another trend that will be interesting to examine is the rise of "sweepers." In the future, a separate model for pitches classified as sweepers can improve the strength of both the slider model as well as the overall Stuff+ calculation.

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References

References have been compiled and are available upon request.