EXCITING BASEBALL:

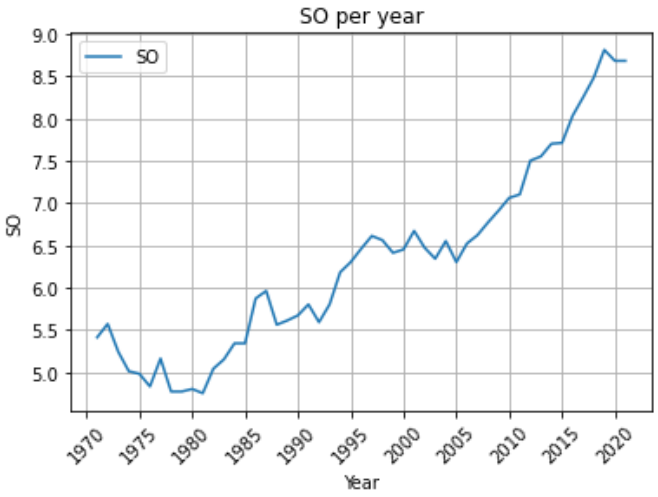
A STICKY SITUATION

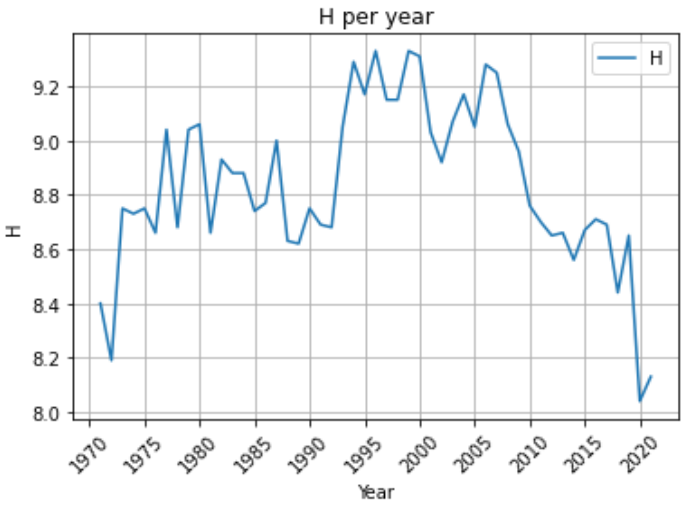
FIRST INNING

It's been described as the hardest thing to do in all of sport: Hit a round ball with a round bat. A player who accomplishes this a third of the time is considered elite. No other sport tolerates such a continuous amount of failure as baseball; the hundred-years-war between pitchers and batters has almost always been won by the pitcher. Consequently, the fleeting moments of excellence where an underdog batter conquers a dominant pitcher are the moments we remember. They're the moments that put fans in the stadium time and time again. Without those moments it's just a game of catch, and who really cares?

Over the last few years the fans have loudly answered: "No one". Baseball fans know that it's hard to get hits; they know that pitchers own the game. Nevertheless, there has to be enough action, enough hitting, to keep fans in the seats. The MLB has recognized this at different times and changed rules to encourage hitting. Whether it was regulating the color of balls to make them easier to see, shrinking ball-parks to boost home runs, or moving the mound back, the league has tried to make the game exciting. The "sticky-stuff" ban that took effect halfway

through the 2021 season is the MLB's response to decreasing levels of interest in America's pastime.

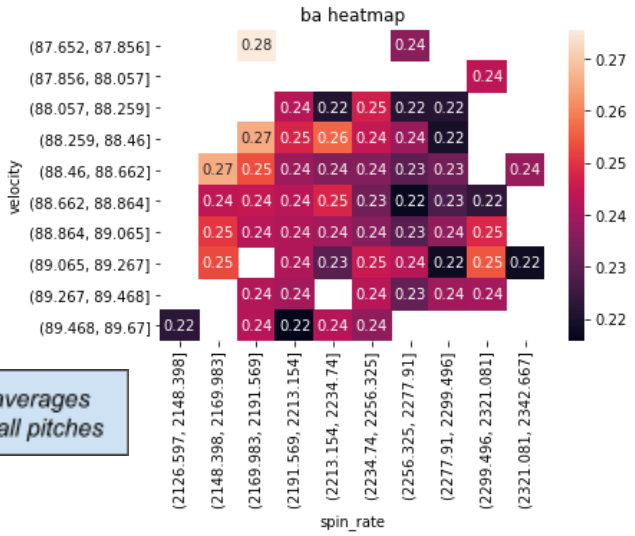




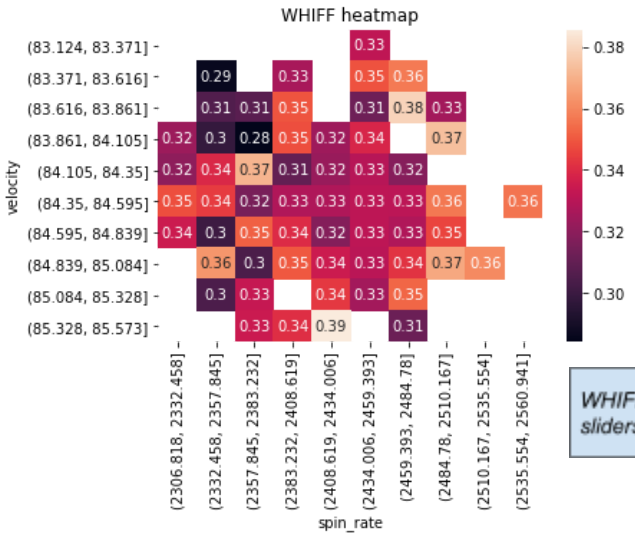
soaring strikeouts and decreasing hits have undoubtedly contributed to the sports decline in popularity

THIRD INNING

Before discussing why the "sticky-stuff" ban was necessary, we need to step back and understand the nature of the problem. In 2015 baseball introduced Statcast to all its parks. Statcast is a tool that captures every facet of the game and quantifies it for statistical analysis. Among the underlying pitching stats recorded, spin rate influences the performance of pitchers the most. High spin four-seam fastballs lead batters to believe that the ball elevates as they swing. High spin sliders (one of the most commonly thrown breaking balls) experience sudden "breaks" and leave batters confused. The heatmaps below display some of this confusion by showing decreasing batting averages and increasing WHIFF (swings-and-misses/ total swings) as spin rate and velocity climb.



batting averages against all pitches



WHIFF against sliders

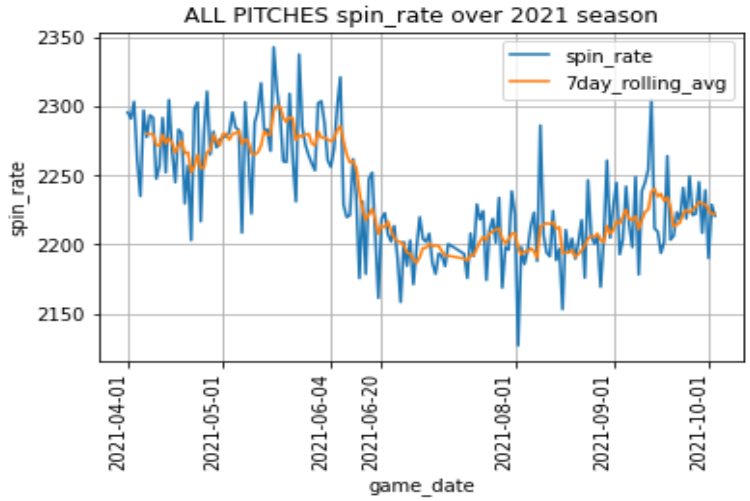
Unsurprisingly, pitchers began searching for ways to increase spin rate. Raise velocity. Change release point. Lengthen arm rotation. As methods were exhausted, one trick was discovered that radically boosted spin: Using foreign substances that increase grip of the ball. Despite its illegality, pitching coaches started teaching their players how to use "sticky-stuff", and teams created under-the-radar chemistry divisions to develop the most effective solutions. Pitchers were swayed in free-agency to join teams who promised to improve their performance with "proprietary" methods. Two months into the 2021 season the problem was out of control.

On June 4th, 2021 the league informed teams that new policies and punishments would soon be implemented to control doctoring of the ball. A little over two weeks later, on June 21st, enforcement of those policies began. Pitchers protested the mid-season decision while batters quietly approved. The results of the rule enforcement were dramatic and drew attention to the "accepted" cheating that had been allowed and encouraged by teams.

Max Scherzer doesn't like being checked for cheating

FIFTH INNING

To analyze the effects of the rule change, let's start by looking at league-wide spin rate averages over the course of the season. On the x-axis key dates are highlighted, specifically

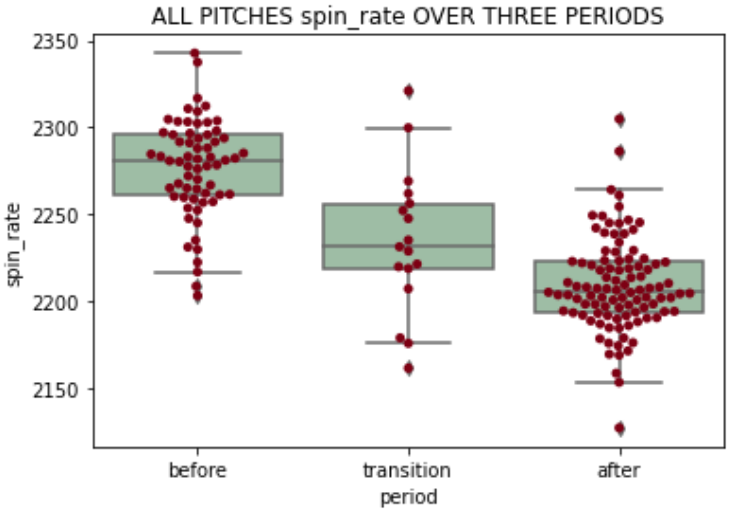


2021-06-04, the day teams were told about the imminent rule change, and 2021-06-20, the last day of non-enforcement. During this “transition” period, teams wisely adjusted their methods to prepare for the league's future enforcement. From June 21st and onward, it's safe to assume that pitchers were no longer applying sticky-stuff to their fingers in fear of suspension and fines. Following the transition it's obvious that the “after” periods baseline is lower than the “before” period and we can prove this statistically by conducting ANOVA* tests.

	Source	SS	DF	MS	F	p-unc	np2
0	period	178936.054777	2	89468.027388	107.672276	1.992774e-31	0.546082
1	Within	148736.308511	179	830.929098	NaN	NaN	NaN

THERE IS A SIGNIFICANT DIFFERENCE IN MEAN spin_rate OVER THREE PERIODS

	A	B	mean(A)	mean(B)	diff	se	T	p-tukey	hedges
0	after	before	2208.851	2276.432	-67.582	4.605	-14.674	0.001	-2.334
1	after	transition	2208.851	2234.308	-25.457	7.557	-3.369	0.003	-0.877
2	before	transition	2276.432	2234.308	42.125	7.865	5.356	0.001	1.447



	Source	SS	DF	MS	F	p-unc	np2
0	period	222884.006259	2	111442.003129	110.345568	5.970380e-32	0.552154
1	Within	180778.611469	179	1009.936377	NaN	NaN	NaN

THERE IS A SIGNIFICANT DIFFERENCE IN MEAN spin_rate OVER THREE PERIODS

	A	B	mean(A)	mean(B)	diff	se	T	p-tukey	hedges
0	after	before	2383.860	2459.204	-75.344	5.077	-14.839	0.001	-2.360
1	after	transition	2383.860	2418.759	-34.899	8.331	-4.189	0.001	-1.091
2	before	transition	2459.204	2418.759	40.445	8.671	4.664	0.001	1.261

In both tests (all pitch types on left, and sliders on right) spin rate dropped significantly with the probability (p-unc) of results occurring by chance nearly zero. Across all pitches a mean difference of -67.58 rpm was observed, and a standardized effect size (hedges column) of -2.33 was reported. This means that the average “after” period spin rate was -2.33 standard deviations below the average “before” period spin rate. An effect size larger than |0.8| is considered large, so -2.33 shows a massive decrease in spin. On the right, the results are worse. Sliders experienced a drop of -75.34 rpm’s in average spin, and an effect size of -2.36 standard deviations. It's not surprising that a pitch highly dependent on spin would be affected by the rule change, but a drop like this is eye-opening. What all this sums up to is that a change in spin rate this large cannot be explained by chance, the ban on foreign substances must be responsible.

SEVENTH INNING

It's important to remember though, that the rule change was designed to generate more action during games. Yes, banning sticky stuff lowers spin rate, but the MLB's end goal is more hits, more excitement, more engagement. High spin leads to more swings and misses (WHIFF) , and higher WHIFF results in lower batting averages. Although this is intuitive (more swings and misses equals more outs, more outs equals less hits), the matrix below shows the positive correlation between spin rate and WHIFF (R=0.39). When spin rate increases, WHIFF increases.

	ba	spin_rate	velocity	sv_ratio	WHIFF	swstr	hits
ba	1.000000	-0.256629	0.026882	-0.257056	-0.511151	-0.444237	0.948380
spin_rate	-0.256629	1.000000	-0.022370	0.976391	0.394126	0.305353	-0.234907
velocity	0.026882	-0.022370	1.000000	-0.237224	0.045951	0.113008	0.027369
sv_ratio	-0.257056	0.976391	-0.237224	1.000000	0.372917	0.273191	-0.235529
WHIFF	-0.511151	0.394126	0.045951	0.372917	1.000000	0.925314	-0.476829
swstr	-0.444237	0.305353	0.113008	0.273191	0.925314	1.000000	-0.397844
hits	0.948380	-0.234907	0.027369	-0.235529	-0.476829	-0.397844	1.000000

Not surprising. The more unpredictable a ball moves, the harder it is to make contact. Additionally, this matrix confirms our intuition about the negative relationship between WHIFF and batting average (R=-0.51). In fact, in this dataset WHIFF has the greatest influence on batting average.

We can explore this relationship more by creating a simple linear regression model where WHIFF is the independent (or predictor) variable and batting average is the dependent (predicted) variable. Our OLS report tells us that 25.7% (adj R-square) of the variability in batting averages is attributable to the variability of WHIFF; furthermore, it tells us that WHIFF's

OLS Regression Results

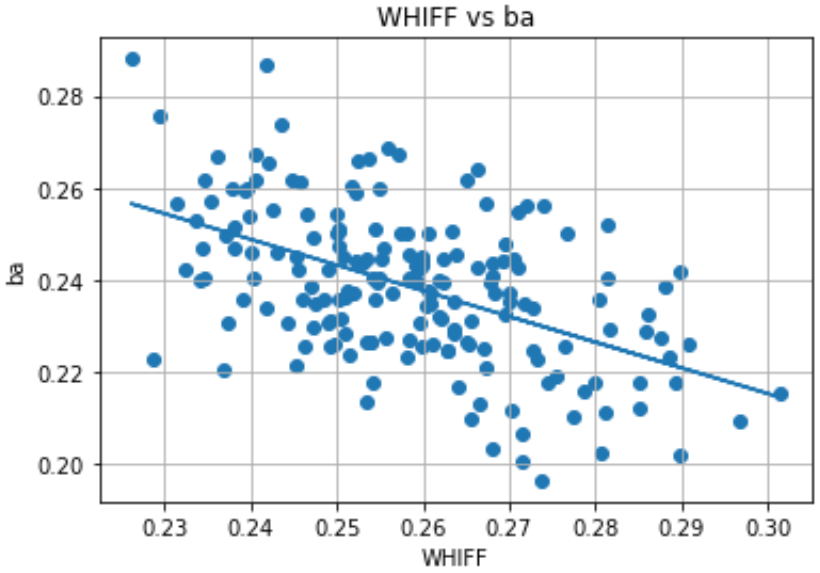
Dep. Variable:	ba	R-squared:	0.261
Model:	OLS	Adj. R-squared:	0.257
Method:	Least Squares	F-statistic:	63.66
Date:	Tue, 14 Dec 2021	Prob (F-statistic):	1.67e-13
Time:	20:37:08	Log-Likelihood:	516.27
No. Observations:	182	AIC:	-1029.
Df Residuals:	180	BIC:	-1022.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.3826	0.018	21.150	0.000	0.347	0.418
WHIFF	-0.5574	0.070	-7.979	0.000	-0.695	-0.420

coefficient is -0.5574 and the model's constant is .3826 (this means if WHIFF equaled zero, we could expect a batter to have an extremely respectable .383 batting average). All together, our simple linear regression model to predict batting average is:

"batting average= -.5574(WHIFF) + .3826"

Other variables, such as sv_ratio (spin rate/ velocity), could be added to this model to increase the adjusted R-square value but the increase is minimal. In an effort to remain parsimonious with our model, and to avoid collinearity issues we can ignore minimal gains in accuracy and move forward. The scatter plot below fits a line through all pitch data from the 2021 season using the formula generated in the OLS report



Understanding the relationships between spin rate, WHIFF and batting average leads us to the reason why the MLB banned the use of foreign substances on balls. They want more hits.

NINTH INNING

Did the rule change work? Are there more hits and higher batting averages? These questions are quickly answered using Welch's t-test* to compare mean hits and batting averages before and after the rule change.

t-Test for BEFORE and AFTER hits stats:

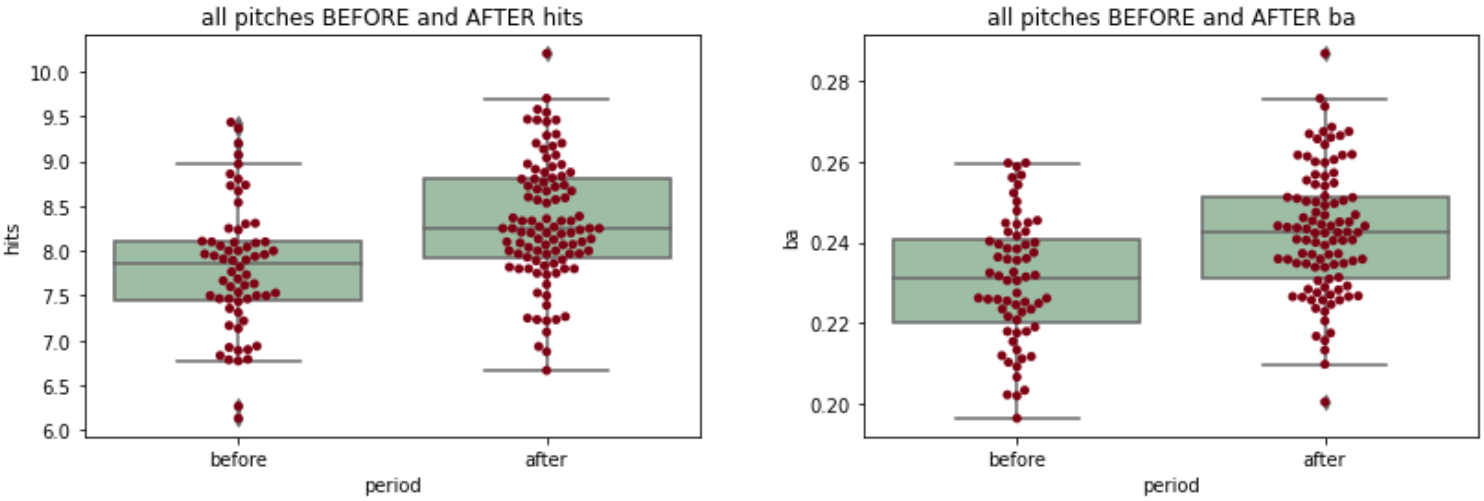
	T	dof	alternative	p-val	CI95%	cohen-d
T-test	-4.567166	129.068205	two-sided	0.000011	[-0.73, -0.29]	0.738176

THERE IS A SIGNIFICANT DIFFERENCE IN MEAN hits
MEDIUM EFFECT

t-Test for BEFORE and AFTER ba stats:

	T	dof	alternative	p-val	CI95%	cohen-d
T-test	-4.896021	135.023218	two-sided	0.000003	[-0.02, -0.01]	0.780761

THERE IS A SIGNIFICANT DIFFERENCE IN MEAN ba
MEDIUM EFFECT



This is what the league wanted. With p-values far below the typical .05 threshold, we can confidently say that hits and batting averages increased after the rule change. T-test results on the previous page give us a standardized effect size (cohen-d) of 0.73 for hits, and an effect size of 0.78 for batting average. For a sport that relentlessly forces even the best batters to regress to their mean averages, a fairly large effect size such as this is encouraging.

Armed with this information, we can make evereal key inferences about the 2021 season.

1. the sticky-stuff ban resulted in a significant drop in spin rate
2. lower spin results in lower WHIFF
3. lower WHIFF results in more action (higher batting averages, more hits)

Enforcing the ban on foreign substances was effective. Next season, fans should expect to see more balls in play. They should expect to see more dramatic moments. They should be excited. Even though pitchers will continue to win most battles against hitters, the odds are significantly more even. Major League Baseball wants to energize the sport and put it back in its rightful seat as America's pastime. The 2021 rule change brings them closer to realizing that goal.

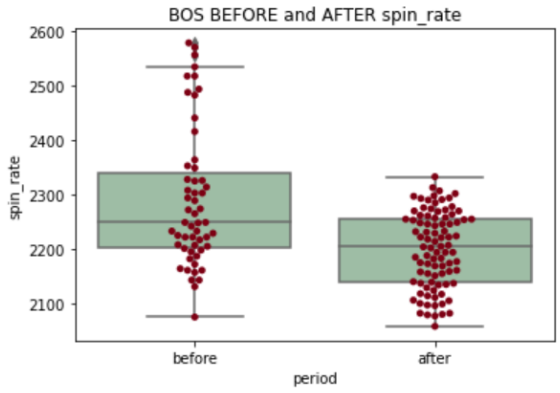
EXTRA INNINGS

In case you were wondering: The Boston Red Sox sat just outside the top five “cheating” teams as the sixth most affected by the rule enforcement. Thanks Garrett Richards.

t-Test for BOS BEFORE and AFTER spin_rate stats:

	T	dof	alternative	p-val	CI95%	cohen-d
T-test	4.831098	73.947216	two-sided	0.000007	[53.09, 127.62]	0.94395

for BOS there is a SIGNIFICANT DIFFERENCE IN MEAN spin_rate
LARGE EFFECT



* All tests were conducted under the assumption that data was distributed normally and exhibited homogeneity of variance. Shapiro-Wilks tests were used to test normality, and when significant p-values were observed, histograms and qq-plots were generated to aid in determining whether it was reasonable to assume normality. In the end it was reasonable to assume all data is normally distributed. Levene, and Bartlett tests were used to test for equal variances. All data analysed showed equal variability.