Statistical Learning: Project Presentation

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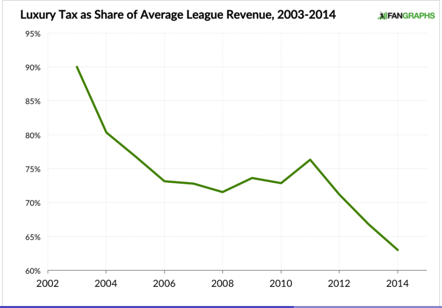
Research Question

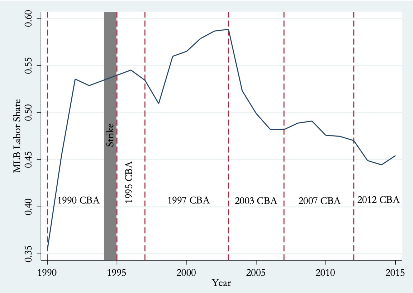
The MLB's "luxury tax," implemented in the 2003 Collective Bargaining Agreement, is a rule penalizing franchises whose team payroll for a given year exceeds an agreed threshold. This project attempts to test the tax's effect on quality of play by studying the number of above-rookie retirees (referred to here as "couldabeens") as a share of total retirements.

Why does the luxury tax matter?

Although originally pitched as a way to "even the playing field," the luxury tax has increasingly functioned as a salary cap. Existing literature has established a continuing decline in labor share in the MLB since the 2003 CBA (Bradbury, 2019).

$$\textit{Labor Share} = \frac{\textit{Total MLB Revenue}}{\textit{Total MLB Player Payroll}}$$





Theory

How might the “luxury tax” increase the number of above-rookie retirees?

- Players don’t gain free agency until six years of MLB service time, making rookies cheaper than veterans.
- Farm teams not counted towards salary threshold, guaranteeing reserve pool of rookies.
- Teams direct limited budget towards retaining a handful of elite veterans, filling out roster with rookies.
- Hypothesis: Good-but-not-Mike-Trout veterans replaced with marginally inferior rookies to stay below salary threshold.

Methods: The Data

We got our data from https://stathead.com/baseball/ and divided it into four data sets:

1. Rookie pitchers
2. Rookie position players
3. Retired pitchers
4. Retired position players

Methods: WAR

Wins Above Replacement, or WAR, is a baseball statistic which seeks to measure a player's total contribution to his team. A WAR of 0.3 means the player's team will win 0.3 more games per season than if he had been substituted for a replacement-level player.

We define the WAR statistic for position players and pitchers differently, as follows. . .

Position WAR

Position WAR:

$$WAR = \frac{(Player\ Runs - Avg\ Runs) + (Avg\ Runs - Replacement\ Runs)}{Game\ Runs\ to\ Wins\ Estimator}$$

where

$$\begin{aligned} Player\ Runs = Batting\ Runs + Baserunning\ Runs + Double\ Play\ Runs + \\ Fielding\ Runs + Positional\ Adjustment \end{aligned}$$

Pitcher WAR

Pitcher WAR:

Abrev.	Meaning
AARA	Adjusted Avg Runs Allowed
APRA	Adjusted Player Runs Allowed
ARRA	Adjusted Replacement Runs Allowed

Table 1: Key

$$WAR = \frac{(AARA - APRA) + (ARRA - AARA)}{Game\ Runs\ to\ Wins\ Estimator}$$

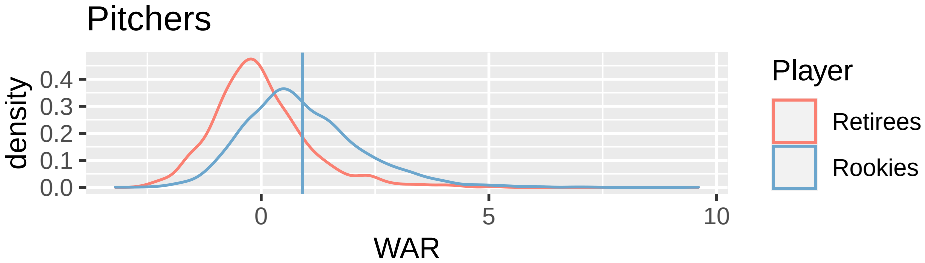
However, the "replacement-level player" used in WAR is an estimate for the average *midseason* replacement. Being better than a midseason replacement does not necessarily make you better than the generation of rookies *actually* replacing you.

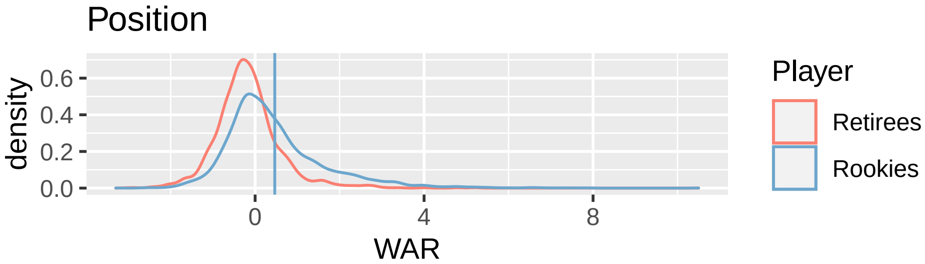
Methods: The Couldabeen Classifier

We want to calculate whether a given retiring player is better than the average rookie replacing him. For a given year Y, we first compute the mean rookie's WAR, call it $Rookie_Y$. Then, we construct the corresponding classifier for "couldabeen" status C of a given retired player p (from the year Y) to be as follows:

$$C(p) = \begin{cases} True, \text{WAR}_p \geq Rookie_Y \\ False, \text{WAR}_p < Rookie_Y \end{cases}$$

Visualization: Couldabeen Classification



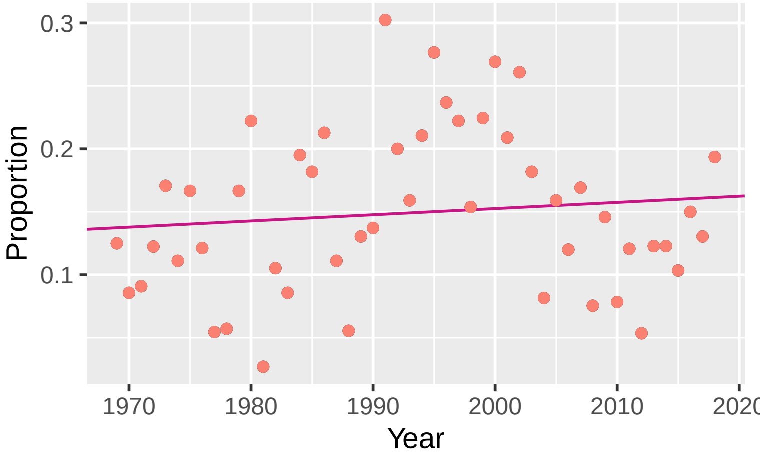


Methods: Modeling

Linear Model: After classifying all retired players, get proportion of "couldbaeen" retirees and call this `prop`.

- As such, we now have 50 data points (for each year), so we run a linear model fitting `Year ~ prop`.
- Because there will always be "couldabeens", we do not expect a large effect size and hence a very significant result.
- If our research hypothesis is correct (that there is an effect), we expect to see a positive coefficient for β_{Year}.

Linear Model: Year



A Confounding Variable: *Moneyball* and the Sabermetric Revolution

"Sabermetrics is the search for objective knowledge about baseball through analysis of the statistical record." - from the Society for American Baseball Research, or SABR

A Confounding Variable: *Moneyball* and the Sabermetric Revolution

Timeline:

1977: Bill James, inventor of term “sabermetrics,” publishes first “book”: *1977 Baseball Abstract*. It sells 75 copies.

1997: Billy Beane promoted to general manager of Oakland Athletics. He’s ready every *Baseball Abstract* ever published.

(October 2002): Athletics finish season with MLB’s best record and second-lowest budget.

(November 2002): Beane declines $12.5 million offer from Boston Red Sox. Boston hires Bill James instead.

(June 2003): Michael Lewis publishes *Moneyball: The Art of Winning an Unfair Game*.

A Confounding Variable: *Moneyball* and the Sabermetric Revolution

(October 2004): Boston wins their first World Series since 1918.

(2006): *Time* lists Bill James among “100 Most Influential People in the World.” Nearly every MLB franchise employs a sabermetrics team.

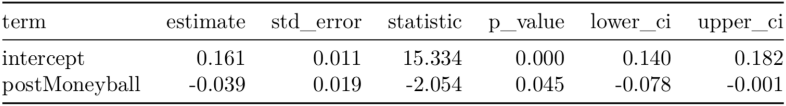
> *"[Presidential politics] reminded me of baseball, when you see the same recycled clichés and conventional wisdoms over and over again, some of which isn’t very wise." - Former *Baseball Prospectus* partner Nate Silver, on why he founded *538**

Hypothesis Test: Why Split the Data?

Since the release of Moneyball in 2003 seems to be an important **confounding variable**, we perform a hypothesis test on the `postMoneyball` classifier of a year Y, defined as follows:

$$\text{postMoneyball}(Y) = \begin{cases} \textit{True}, Y > 2003 \\ \textit{False}, Y \leq 2003 \end{cases}$$

- We fit a model `Year ~ postMoneyball` and perform *LSS*.

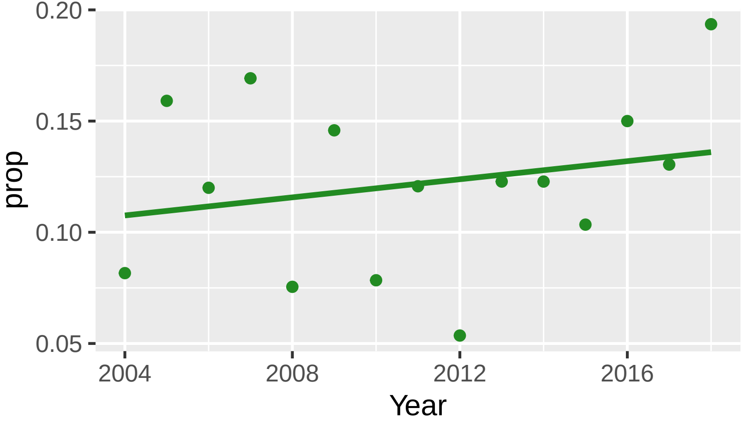


term	estimate	std_error	statistic	p_value	lower_ci	upper_ci
intercept	0.161	0.011	15.334	0.000	0.140	0.182
postMoneyball	-0.039	0.019	-2.054	0.045	-0.078	-0.001

Linear Model on Year (Post-Moneyball)

Linear Model: After partitioning the dataset, we classify the retirees and get proportion of “couldbaeen” retirees that year, we call this `prop`.

- We run a linear model fitting `Year ~ prop`.



Linear Model on Year

Post-Moneyball era

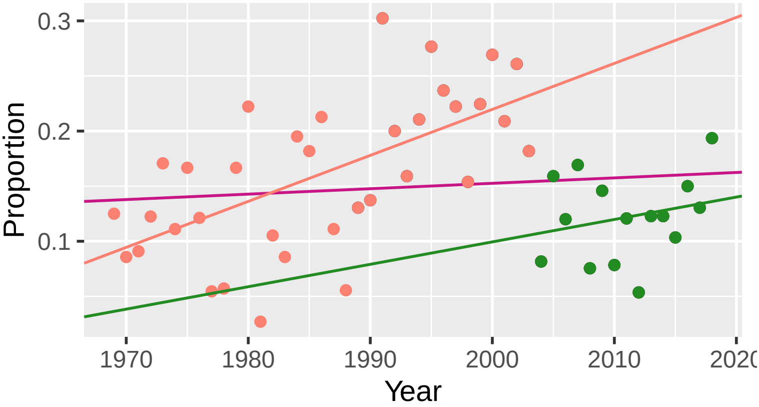
- $\beta_{Year} = 0.002034$.
- $\beta_{Year} > 0$ supports the hypothesis that there is an increasing rate of couldabeens since the luxury tax.
- β_{Year} is not statistically with a high p-value of 0.398.

Pre-Moneyball era

- $\beta_{Year} = 0.004174$.
- β_{Year} is statistically significant with a high p-value of $p \approx 0$.
- Since the pre-Moneyball era had more data points, this may explain the lower p-value.

Simpson's Paradox

- Partitioning and fitting linear model with `Year ~ prop` yields $\beta_{Year} > 0$ in both partitions.
- However, if we do not make the partition, we find that $\beta_{Year} \approx 0$.
- This is in fact *Simpson's Paradox*.



What next?

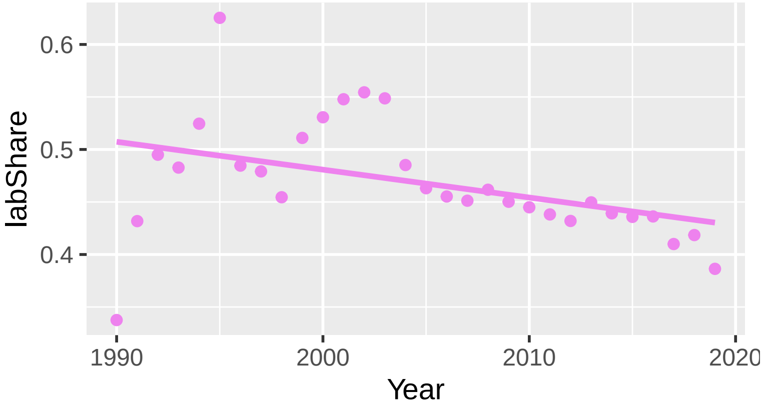
So far, we have fit some linear models seeing the effect sizes of `Year` on the response `prop`. But `Year` is no mighty predictor. . .

- We know that we must partition the dataset into pre-Moneyball and post-Moneyball due to the confounding variable.
- From the linear model on the pre-Moneyball era, we find that $\beta_{Year} > 0$, suggesting that it is *certainly possible* that the rule had an effect on the game.
- Nonetheless, $p = 0.3$ is statistically insignificant. . .
- Resample, or bring in new data.

A New Approach: Labor Share

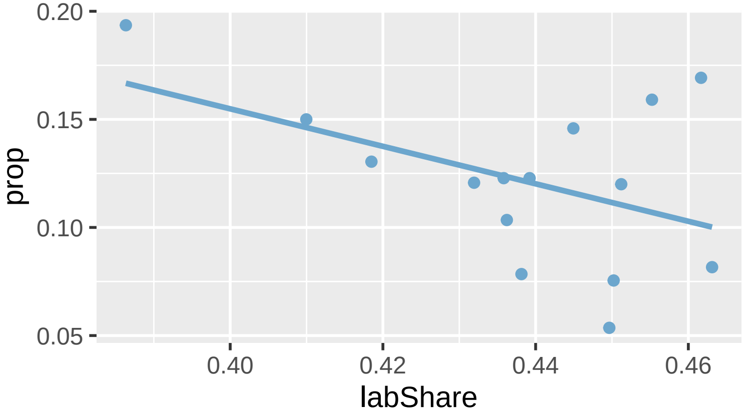
Since our couldabeen proportions are sorted by year, we needed year-sorted data. So, we used the Total Revenue and Total Payroll.

$$laborShare(Y) = \frac{totalPayroll(Y)}{totalRevenue(Y)}$$

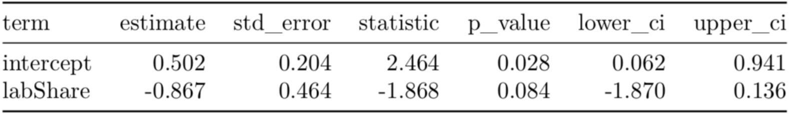


Linear Model: Labor Share

- In fact, study by [Bradbury] shows labor share is decreasing due to the rule. . .
- So how is `laborShare` affecting `prop`? We fit `prop ~ laborShare`:



Results: Linear Model (Labor Share)



term	estimate	std_error	statistic	p_value	lower_ci	upper_ci
intercept	0.502	0.204	2.464	0.028	0.062	0.941
labShare	-0.867	0.464	-1.868	0.084	-1.870	0.136

- Alas, we find $\beta_{LabShare} = -0.867$ with a *p*-value of $p = 0.084$.
- Labor share is indeed **negatively** correlated to proportion of couldabeens.
- Research paper by [Bradbury] conveys that labor share is indeed diminshing due to the *luxury tax*.

Conclusion

To summarize:

- No correlation between year and proportion of couldabeens across entire 50-year span. ($\beta_{Year} \approx 0$)
- Positive but non-significant relationship between year and proportion of couldabeens when partitioned into pre- and post-*Moneyball* eras.
- (Hypothesis Test) Strongly significant negative relationship between publication of *Moneyball* and proportion of couldabeens. ($p = 0.045$)
- Somewhat significant relationship between labor share and proportion of couldabeens in post-*Moneyball* era. ($p = 0.084$)

References

1. https://stathead.com/baseball/
2. Bradbury, John Charles. “What Explains Labor’s Declining Share of Revenue in Major League Baseball?” (2019).
3. https://blogs.fangraphs.com/mlbs-evolving-luxury-tax/