

The Value of Advanced Metrics in Baseball

Chris Callender

April 27, 2025

1 Abstract

Baseball is a game of numbers and statistics. The game is becoming more analytical, and many teams are changing their approach to winning. In this paper, we will examine wOBA, wRC+, and OPS+, which are relatively new metrics. In my previous research, I determined that WAR is the most useful metric for determining a player's value, so in this paper, we will look at the impact these metrics have on WAR.

2 Introduction

We will start by gathering data on some of the greatest players of all time, including Babe Ruth, Barry Bonds, Ted Williams, and many more. We will observe their career metrics, then use statistics, such as correlation and principal component analysis (PCA), to determine if they are valuable metrics. Finally, we will build a machine learning model to predict WAR.

Note: All data is gathered from Fangraphs, except for OPS+ which is from baseball reference

3 Methods

Let's start by defining some metrics:

3.1 wRC+

$$wRC+ = \frac{(\frac{wRAA}{PA} + \frac{lgR}{PA}) + (\frac{lgR}{PA} - (\text{park factor} \times \frac{lgR}{PA}))}{\frac{\text{league wRC}}{PA} (\text{not including pitchers})} \times 100$$

wRC+ measures a player's hitting ability by determining how many runs they create. It is adjusted for league conditions and park effects. That is, a 100 wRC+ is equivalent for a Rockies' player that plays the majority of their games at Coors Field and a 100 wRC+ for a Padres' player that plays the majority of their games at Petco Park.

3.2 wOBA

$$wOBA = \frac{.69 \times uBB + .72 \times HBP + .89 \times 1B + 1.27 \times 2B + 1.62 \times 3B + 2.10 \times HR}{AB + BB - IBB + SF + HBP}$$

Note: The factors that each outcome is multiplied by, i.e. .69, .72, .89, ..., vary by year, but they are always relatively similar.

wOBA measures hitting ability by assigning a weight to each possible plate appearance outcome. For example, a home run has more weight than a single. We can think of wOBA as a better version of OPS, since it combines aspects of OBP and SLG. That is, it considers walks like OBP, but it also weights hits accordingly, similar to SLG. However, it is better than OPS since it weights each outcome in one metrics, rather than just adding two metrics together.

3.3 OPS+

$$OPS+ = \left(\frac{OBP}{lgOBP} + \frac{SLG}{lgSLG} - 1 \right) \times 100$$

OPS+ adjusts OPS for league and ballpark factors, as well as adjusts the scale so that 100 is league average. A 150 OPS+ would be 50% better than average, and a 80 OPS+ would be 20% worse than average. This makes OPS+ much easier to read and understand.

4 Results

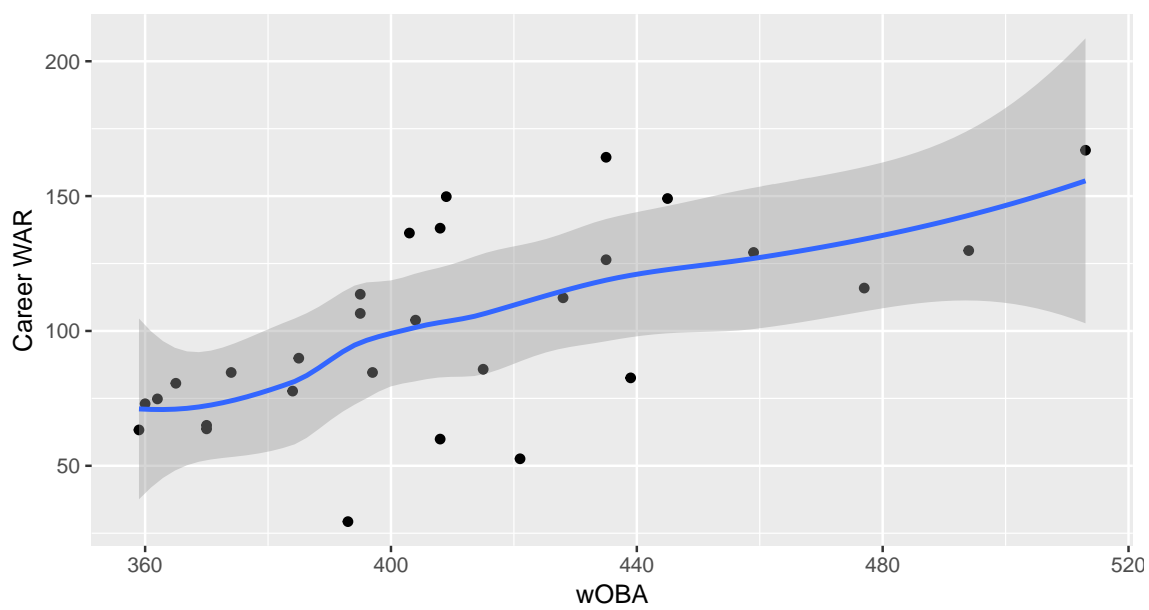
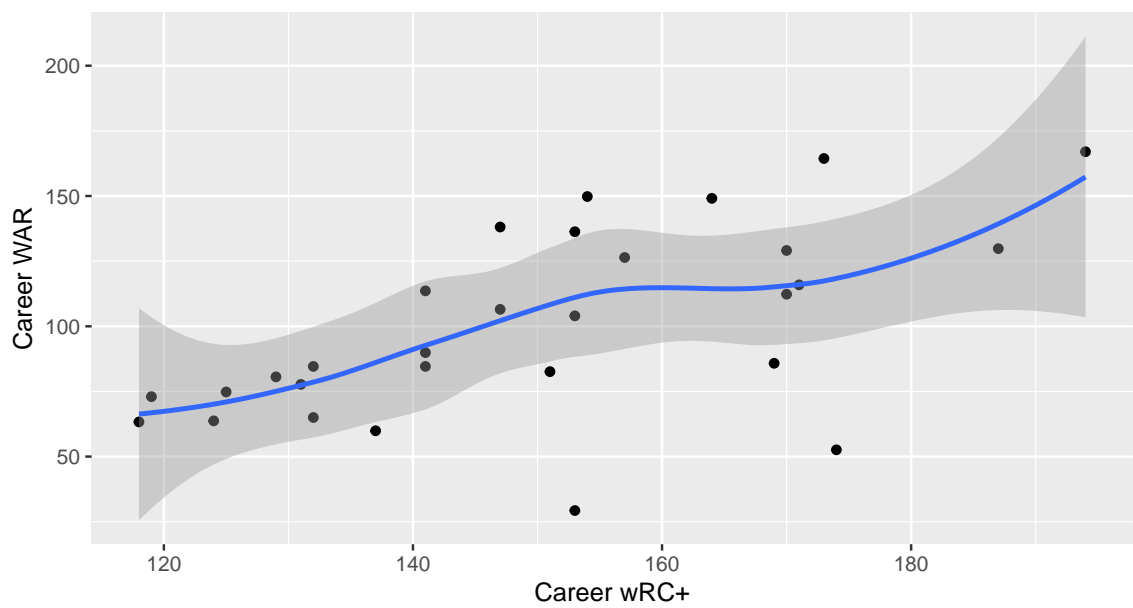
By looking at the correlation table, we can see that wOBA, OPS+, and wRC+ are highly correlated with WAR. This means that a good wOBA usually means a high WAR. Similarly, a high OPS+ and a high wRC+ also lead to a high WAR.

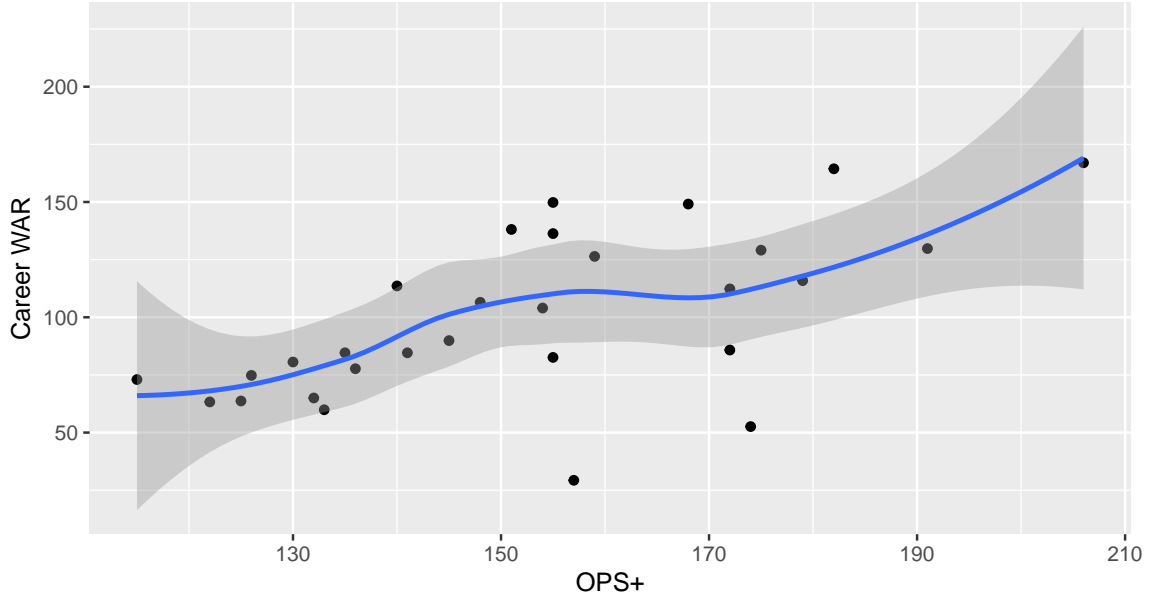
	WAR	wRC+	G	PA	HR	AVG	OBP	SLG	wOBA	OPS+	OPS
WAR	1	0.5985789	0.6375944	0.6387873	0.4432843	0.4909608	0.6047155	0.4432681	0.6372752	0.619657	0.543309
wRC+	0.5985789	1	-0.1224712	-0.1072578	0.2678884	0.4701583	0.8830468	0.8711631	0.915806	0.992383	0.942207
G	0.6375944	-0.122471	1	0.9932806	0.4441735	0.173191	-0.027114	-0.164254	-0.054113	-0.09165	-0.120343
PA	0.6387873	-0.107258	0.9932806	1	0.4318464	0.2108283	0.0074165	-0.148172	-0.031362	-0.0794	-0.095455
HR	0.4432843	0.2678884	0.4441735	0.4318464	1	-0.308875	0.1171581	0.5400293	0.2134096	0.297635	0.407179
AVG	0.4909608	0.4701583	0.173191	0.2108284	-0.308875	1	0.6878304	0.2342764	0.6465244	0.470076	0.438545
OBP	0.6047154	0.8830468	-0.0271135	0.0074165	0.1171581	0.6878304	1	0.7116075	0.9319532	0.871999	0.88422
SLG	0.4432681	0.8711631	-0.1642544	-0.1481723	0.5400293	0.2342764	0.7116075	1	0.829545	0.890803	0.957371
wOBA	0.6372752	0.915806	-0.0541133	-0.0313616	0.2134096	0.6465244	0.9319532	0.829545	1	0.921988	0.934647
OPS+	0.6196573	0.9923834	-0.0916483	-0.0793969	0.2976352	0.4700762	0.8719988	0.8908029	0.9219878	1	0.950721
OPS	0.5433092	0.942207	-0.1203434	-0.0954552	0.4071787	0.4385445	0.8842198	0.9573709	0.9346471	0.950721	1

A reason that the correlation is not higher may be that WAR is affected by longevity. Someone that played for one season may have the same career OPS+ or wOBA as someone who played for 20 seasons, but they most likely will not have the same WAR. That is because wOBA, OPS+, and wRC+ are averages, whereas WAR is a running total.

Additionally, Games and Plate Appearances have the highest correlation with WAR. This may be due to players with longer careers accruing more WAR, and better players may tend to have longer careers. However, these are not good ways to judge a player's value, since games and plate appearance do not tell you anything about how a player performs. For example, a player can play in 162 per season, with 600 plate appearances per season, and not be a good player.

Here are the scatterplots for wRC+, wOBA, and OPS+. The line of best fit has positive slope, which means positive correlation with WAR:





Furthermore, we completed PCA to determine which variables explain the greatest amount of variance of the data. We will keep the first 3 components, since they explain 95% of the variation. The first component, which explains the most variance, most heavily weights wRC+, wOBA, OPS+, and OPS. That is, these variables are the most significant in determining a player's value, since they explain the most variance of the data.

	Comp 1	Comp 2	Comp 3
WAR	0.2812718	0.37736288	0.0868303
wRC+	0.3814633	-0.1009217	-0.0338024
G	0.017031	0.60282693	0.0589902
PA	0.025615	0.59879206	0.0805646
HR	0.1425866	0.29755174	-0.6379133
AVG	0.2277114	0.05611833	0.635103
OBP	0.3679553	-0.051754	0.199394
SLG	0.3508792	-0.1084352	-0.3188887
wOBA	0.3846295	-0.0615274	0.101566
OPS+	0.3846026	-0.0826684	-0.0488915
OPS	0.3845465	-0.0933658	-0.1300163

We also created a machine learning model that can predict a player's WAR.

Model Output			True WAR		
	player	WAR		Player	WAR
1	BarryBonds	140.724	1	BarryBonds	164.4
2	TedWilliams	127.68853	2	TedWilliams	129.8
3	BabeRuth	137.50562	3	BabeRuth	167
4	MickeyMantle	115.85792	4	MickeyMantle	112.3
5	HankAaron	126.09869	5	HankAaron	136.3
6	WillieMays	121.68736	6	WillieMays	149.8
7	TyCobb	145.5536	7	TyCobb	149.1
8	HonusVagner	116.80739	8	HonusVagner	138.1
9	StanMusial	129.97452	9	StanMusial	126.4
10	MikeTrout	79.8912	10	MikeTrout	85.8
11	KenGriffey Jr	82.27019	11	KenGriffey Jr	77.7
12	LouGehrig	119.46103	12	LouGehrig	115.9
13	AaronJudge	65.15491	13	AaronJudge	52.6
14	JoeDimaggio	86.16774	14	JoeDimaggio	82.6
15	ShoheiOhtani	52.29069	15	ShoheiOhtani	29.3
16	FrankRobinson	111.12651	16	FrankRobinson	104
17	MikeSchmidt	91.35004	17	MikeSchmidt	106.5
18	RobertoClemente	77.02873	18	RobertoClemente	80.6
19	RogersHornsby	125.53564	19	RogersHornsby	129.1
20	AlbertPujols	105.18378	20	AlbertPujols	89.9
21	AlexRodriguez	100.80058	21	AlexRodriguez	113.6
22	JohnnyBench	71.23756	22	JohnnyBench	74.8
23	JackieRobinson	63.45793	23	JackieRobinson	59.9
24	ChipperJones	88.15615	24	ChipperJones	84.6
25	GeorgesBrett	81.0394	25	GeorgesBrett	84.6
26	ErnieBanks	66.85566	26	ErnieBanks	63.3
27	TonyGwynn	86.24755	27	TonyGwynn	65
28	YogiBerra	67.25866	28	YogiBerra	63.7
29	DerekJeter	76.54495	29	DerekJeter	73

The r^2 value is .9215. That is a high r^2 value, so that means the model is effective.

5 Conclusion

In conclusion, wRC+, wOBA, and OPS+ are the greatest statistics to determine a player's hitting ability. WAR is the greatest statistic for determining a player's overall ability since it encompasses every aspect of the game, not just hitting.

Future research could involve more statistics. There are many new advanced baseball metrics. We just looked at some of them in this paper. You can look at metrics such as BABIP, xwOBA, wRAA, and many more. Also, statcast, which was created in 2015, has changed the game and led to many valuable new metrics. It may also be interesting to study some pitching metrics. This paper just looked at hitting, but there are many valuable pitching metrics, such as FIP, xERA, and HardHit%.

6 References

1. "Baseball Statistics and Analysis", <https://www.fangraphs.com/>.
2. "MLB Stats, Scores, History, and Records", <https://www.baseball-reference.com/>.
3. "On-base Plus Slugging Plus (OPS+)", <https://www.mlb.com/glossary/advanced-stats/on-base-plus-slugging-plus/>.
4. "Weighted On-base Average (wOBA)", <https://www.mlb.com/glossary/advanced-stats/weighted-on-base-average/>.
5. "Weighted Runs Created Plus (wRC+)", <https://www.mlb.com/glossary/advanced-stats/weighted-runs-created-plus/>.

7 Appendix

Player	WAR	wRC+	G	PA	HR	AVG	OBP	SLG	wOBA	OPS+
Barry Bonds	164.4	173	2986	12606	762	298	444	607	435	182
Ted Williams	129.8	187	2292	9791	521	344	482	634	494	191
Babe Ruth	167.0	194	2503	10616	714	342	474	690	513	206
Mickey Mantle	112.3	170	2401	9909	536	298	421	557	428	172
Hank Aaron	136.3	153	3298	13940	755	305	374	555	403	155
Willie Mays	149.8	154	3005	12541	660	301	384	557	409	155
Ty Cobb	149.1	164	3035	13072	117	366	433	512	445	168
Honus Wagner	138.1	147	2792	11739	101	327	391	466	408	151
Stan Musial	126.4	157	3026	12712	475	331	417	559	435	159
Mike Trout	85.8	169	1529	6697	381	298	410	580	415	172
Ken Griffey Jr	77.7	131	2671	11304	630	284	370	538	384	136
Lou Gehrig	115.9	171	2164	9660	493	340	447	632	477	179
Aaron Judge	52.6	174	1005	4379	321	289	406	607	421	174
Joe Dimaggio	82.6	151	1736	7671	361	325	398	579	439	155
Shohei Ohtani	29.3	153	889	3667	229	282	372	575	393	157
Frank Robinson	104.0	153	2808	11743	586	294	389	537	404	154
Mike Schmidt	106.5	147	2404	10062	548	267	380	527	395	148
Roberto Clemente	80.6	129	2433	10212	240	317	359	475	365	130
Rogers Hornsby	129.1	170	2259	9475	301	358	434	577	459	175
Albert Pujols	89.9	141	3080	13041	703	296	374	544	385	145
Alex Rodriguez	113.6	141	2784	12207	696	295	380	550	395	140
Johnny Bench	74.8	125	2158	8669	389	267	342	476	362	126
Josh Gibson	44.5	202	598	2490	165	374	458	720	521	214
Jackie Robinson	59.9	137	1416	5938	141	313	410	477	408	133
Chipper Jones	84.6	141	2499	10614	468	303	401	529	397	141
George Brett	84.6	132	2707	11624	317	305	369	487	374	135
Ernie Banks	63.3	118	2528	10395	512	274	330	500	359	122
Tony Gwynn	65.0	132	2440	10232	135	338	388	459	370	132
Yogi Berra	63.7	124	2120	8364	358	285	348	482	370	125
Derek Jeter	73.0	119	2747	12602	260	310	377	440	360	115