Analysis of the pit crew performance and its relationship to the Formula 1 championship standings

Actuarial Data Science

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Introduction

- Formula 1 is a sport of precision, where the cars are **battling for every tenth of seconds**
- During a race, cars spend **dozens of seconds in the pit lane**
- **Car performance and drivers' skills** are often commented
- For this presentation, we will look at the importance of the **pit stop efficiency on overall performance in Formula 1**

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Data Visualization

- **Several dataframes:** lap times, pit stops, circuits, drivers, races, status, driver standings, results, and constructors linked together through **driver IDs** and **race IDs.**

	raceId	driverId	stop	lap	time	duration	milliseconds
0	841	153	1	1	17:05:23	26.898	26898
1	841	30	1	1	17:05:52	25.021	25021
2	841	17	1	11	17:20:48	23.426	23426
3	841	4	1	12	17:22:34	23.251	23251
4	841	13	1	13	17:24:10	23.842	23842

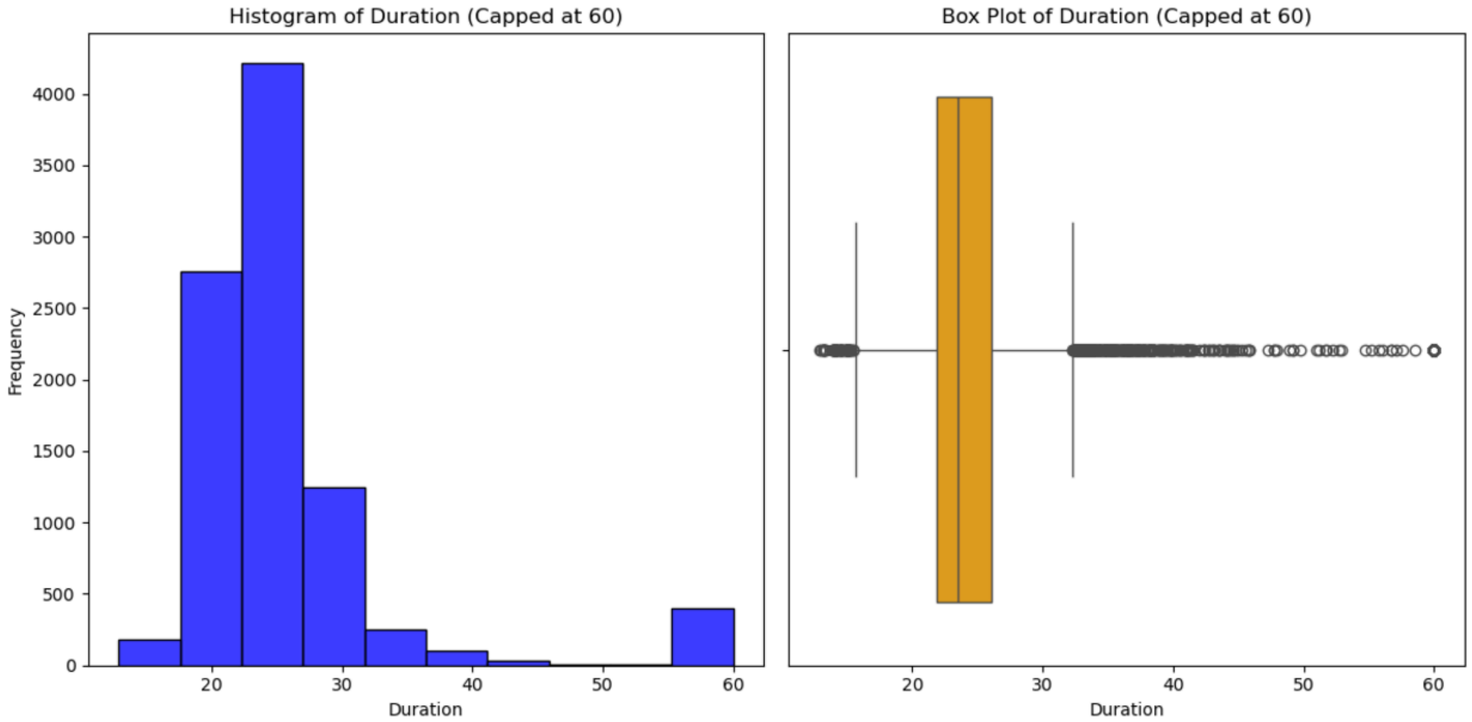
Original pit stop dataframe

	stop	duration	name	year	driverRef
0	1	26.898	Australian Grand Prix	2011	alguersuari
1	1	23.426	Australian Grand Prix	2011	webber
2	1	23.251	Australian Grand Prix	2011	alonso
3	1	23.842	Australian Grand Prix	2011	massa
4	1	22.603	Australian Grand Prix	2011	vettel

Transformed pit stop dataframe

- “Duration” converted to **float**
- **No NaN**
- 9203 observations

Data Visualization



- mean = 82.347, median = 23.529
- many outliers

PIT STOP CHAMPIONSHIP

Hypothesis

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
25	18	15	12	10	8	6	4	2	1

- If a driver doesn’t finish the race or finishes with a delay of more than 3 laps, he is considered as **DNF**
- We consider only the seasons **between 2011 and 2023**
- We rank the drivers by their **average duration in the pit lane for each race**
- We award the **same number of points as the official championship**

Results

driverRef	points	pit_points	rank_std	pit_rank
hamilton	384.0	65	1	13
rosberg	317.0	86	2	10
ricciardo	238.0	219	3	1
bottas	186.0	72	4	11
vettel	167.0	185	5	4
alonso	161.0	208	6	2
massa	134.0	113	7	7
button	126.0	161	8	5
hulkenberg	96.0	99	9	9
perez	59.0	58	10	14
kevin_magnussen	55.0	200	11	3
raikkonen	55.0	118	12	6
vergne	22.0	20	13	19
kvyat	8.0	31	15	16
grosjean	8.0	106	14	8
jules_bianchi	2.0	2	17	22
maldonado	2.0	67	16	12
stevens	0.0	0	22	23
sutil	0.0	12	23	20
gutierrez	0.0	20	24	18

Drivers' Ranking 2014

driverRef	points	pit_points	rank_std	pit_rank
hamilton	381.0	271	1	1
rosberg	322.0	209	2	3
vettel	278.0	239	3	2
raikkonen	150.0	155	4	4
bottas	136.0	96	5	8
massa	121.0	90	6	9
kvyat	95.0	123	7	5
ricciardo	92.0	102	8	7
perez	78.0	108	9	6
hulkenberg	58.0	86	10	10
grosjean	51.0	47	11	16
max_verstappen	49.0	73	12	12
nasr	27.0	34	13	17
maldonado	27.0	69	14	13
sainz	18.0	16	15	18
button	16.0	80	16	11
alonso	11.0	66	17	14
ericsson	9.0	49	18	15
merhi	0.0	6	19	19
rossi	0.0	0	21	20

Drivers' Ranking 2015

Results

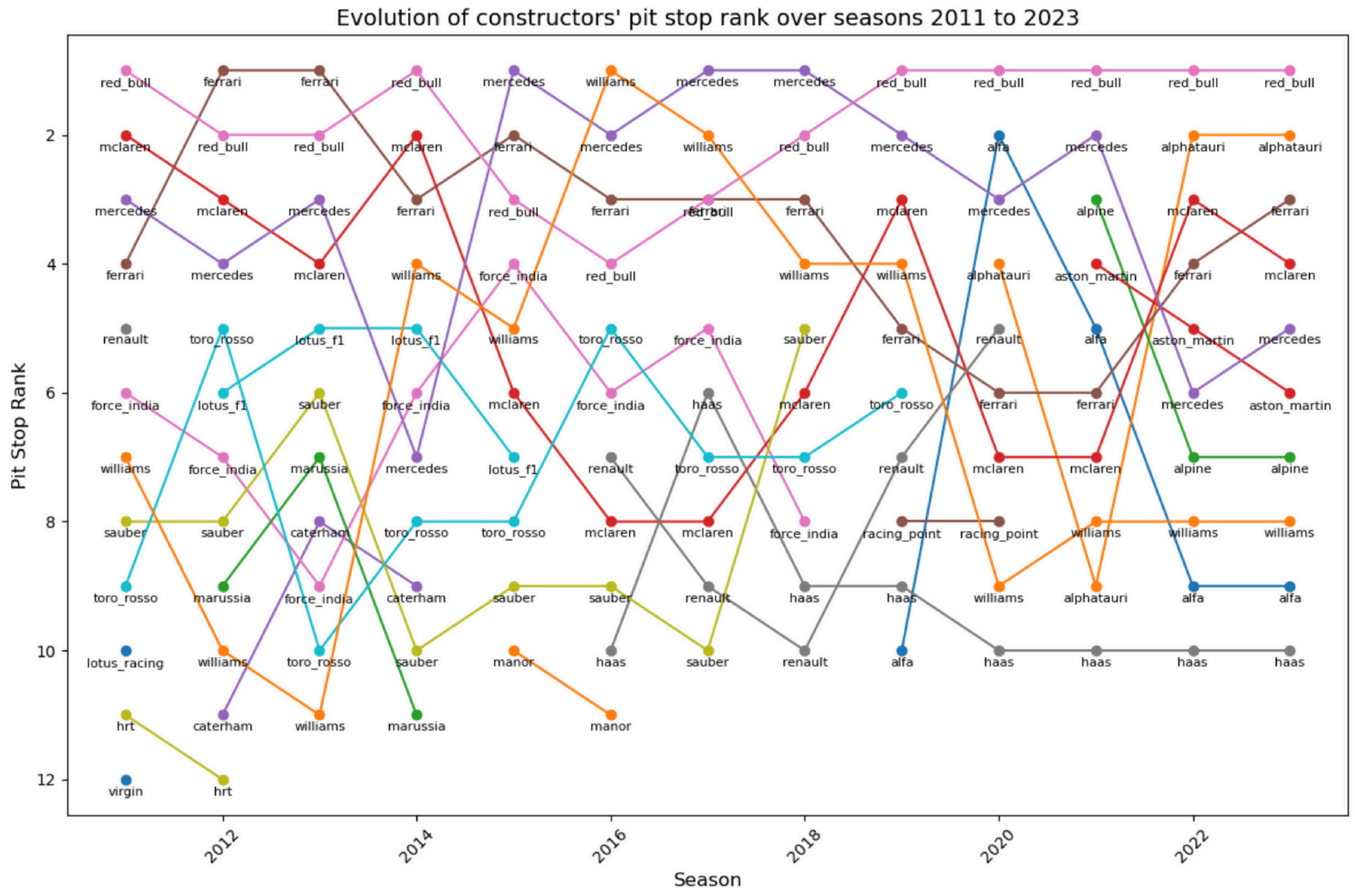
constructorRef	points	pit_points	rank_std	pit_rank
mercedes	701.0	151	1	7
red_bull	405.0	404	2	1
williams	320.0	185	3	4
ferrari	216.0	326	4	3
mclaren	181.0	361	5	2
force_india	155.0	157	6	6
toro_rosso	30.0	51	7	8
lotus_f1	10.0	173	8	5
marussia	2.0	31	9	11
caterham	0.0	48	10	9
sauber	0.0	32	11	10

Constructors' Ranking 2014

constructorRef	points	pit_points	rank_std	pit_rank
mercedes	703.0	480	1	1
ferrari	428.0	394	2	2
williams	257.0	186	3	5
red_bull	187.0	225	4	3
force_india	136.0	194	5	4
lotus_f1	78.0	116	6	7
toro_rosso	67.0	89	7	8
sauber	36.0	83	8	9
mclaren	27.0	146	9	6
manor	0.0	6	10	10

Constructors' Ranking 2015

Results



Evolution of constructors' pit stop rank over seasons 2011 to 2023
Pit Stop Rank
Season
2
4
6
8
10
12
2012
2014
2016
2018
2020
2022
red_bull
mclaren
mercedes
ferrari
renault
force_india
williams
sauber
toro_rosso
lotus_racing
hrt
virgin
ferrari
red_bull
mclaren
mercedes
toro_rosso
lotus_f1
force_india
sauber
marussia
williams
caterham
hrt
ferrari
red_bull
mercedes
mclaren
lotus_f1
sauber
marussia
caterham
force_india
toro_rosso
williams
red_bull
mclaren
ferrari
williams
lotus_f1
force_india
mercedes
toro_rosso
caterham
sauber
marussia
mercedes
ferrari
red_bull
force_india
williams
mclaren
lotus_f1
toro_rosso
sauber
manor
williams
mercedes
ferrari
red_bull
toro_rosso
force_india
renault
mclaren
sauber
haas
manor
mercedes
williams
force_india
haas
toro_rosso
mclaren
renault
sauber
mercedes
red_bull
ferrari
williams
sauber
mclaren
toro_rosso
force_india
haas
renault
red_bull
mercedes
mclaren
williams
ferrari
toro_rosso
renault
racing_point
haas
alfa
red_bull
alfa
mercedes
alphatauri
renault
ferrari
mclaren
racing_point
williams
haas
red_bull
mercedes
alpine
aston_martin
alfa
ferrari
mclaren
williams
alphatauri
haas
red_bull
alphatauri
mclaren
ferrari
aston_martin
mercedes
alpine
williams
alfa
haas
red_bull
alphatauri
ferrari
mclaren
mercedes
aston_martin
alpine
williams
alfa
haas

Models

Correlation between Constructors' Pit Stop Championship and official constructors' championship:

- **Pearson correlation: 0.7554** (points)
- **Spearman correlation: 0.7380** (ranks)
- **Kendall-Tau correlation: 0.5980** (ranks)

Correlation between Drivers' Pit Stop Championship and official drivers' championship:

- **Pearson correlation: 0.7443** (points)
- **Spearman correlation: 0.7584** (ranks)
- **Kendall-Tau correlation: 0.5842** (ranks)

Models

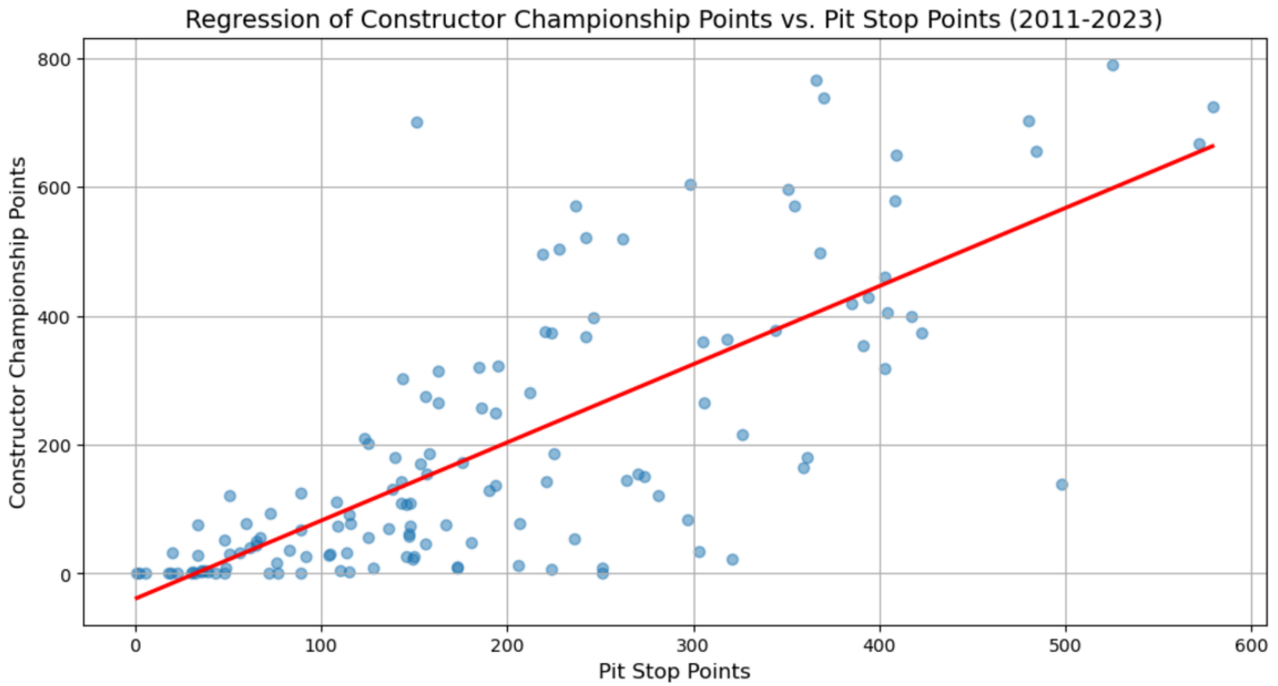
OLS REGRESSION FOR CONSTRUCTORS

OLS Regression Results

Dep. Variable:	points	R-squared:	0.571
Model:	OLS	Adj. R-squared:	0.567
Method:	Least Squares	F-statistic:	179.4
Date:	Tue, 26 Nov 2024	Prob (F-statistic):	1.48e-26
Time:	17:35:05	Log-Likelihood:	-870.99
No. Observations:	137	AIC:	1746.
Df Residuals:	135	BIC:	1752.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-39.1702	21.163	-1.851	0.066	-81.024	2.683
pit_points	1.2129	0.091	13.395	0.000	1.034	1.392

Omnibus:	13.758	Durbin-Watson:	1.857
Prob(Omnibus):	0.001	Jarque-Bera (JB):	24.504
Skew:	0.448	Prob(JB):	4.78e-06
Kurtosis:	4.868	Cond. No.	412.



Models

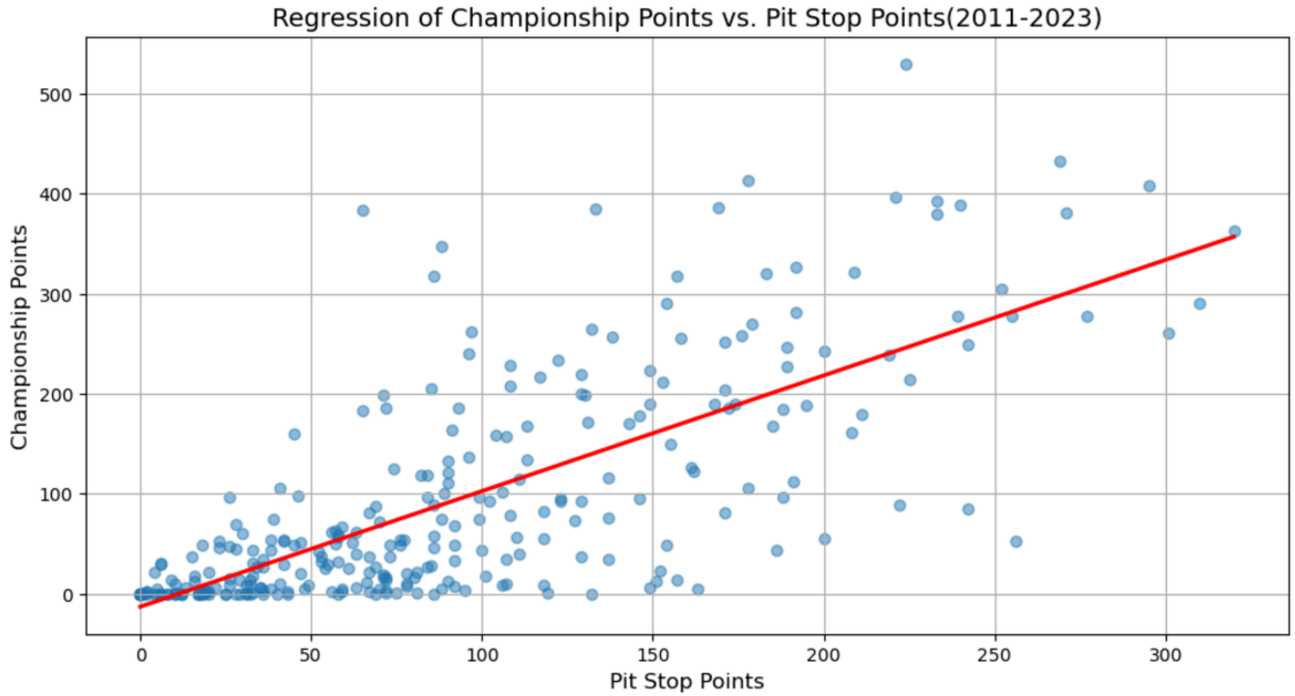
OLS REGRESSION FOR DRIVERS

OLS Regression Results

Dep. Variable:	points	R-squared:	0.554
Model:	OLS	Adj. R-squared:	0.552
Method:	Least Squares	F-statistic:	362.7
Date:	Tue, 26 Nov 2024	Prob (F-statistic):	3.94e-53
Time:	17:34:02	Log-Likelihood:	-1682.5
No. Observations:	294	AIC:	3369.
Df Residuals:	292	BIC:	3376.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-13.1937	6.956	-1.897	0.059	-26.883	0.496
pit_points	1.1565	0.061	19.046	0.000	1.037	1.276

Omnibus:	49.363	Durbin-Watson:	1.447
Prob(Omnibus):	0.000	Jarque-Bera (JB):	120.796
Skew:	0.797	Prob(JB):	5.88e-27
Kurtosis:	5.705	Cond. No.	184.



Models

IMPROVEMENT AND EXTENSIONS

- Adding more variables in the OLS regression (e.g. age, years in F1, wet or dry race, ...)
- Use other types of regression like quadratic regression, spline regression,...
- Use another variable to represent the pit stop efficiency
- Stopping time instead of the time spent in the pit lane to isolate the pit crew technicians efficiency
- Analyze relationships across seasons to identify trends over time
- Investigate causal relationships

Conclusion

- Top teams consistently perform better
- High correlation and R-squared between our Pit Stop Championship and the official championships
- Seasonal variability and model improvement