Introduction

- This project is based on an investigation to what extent is the once time application of this spray impact the durability of the tyres, in particular the tread lifetimes.
- **Hypothesis:** Treated tyres experience less wear than untreated tyres
- **Study design:** 30 employees over 8 months; 15 treated, 15 untreated
- We will summarize and describe the driving habits of the drivers.

Data Collection

- Daily measurements for each tyre (FL, FR, BL, BR):
  - Number of shocks experienced
  - Distance travelled (km)
  - Tread depth (mm)
- Data anonymized for each driver using IDs (ID1…ID30)

	A	B	C	D	E	F	G	H	I	J
1	day	numshocksFL	numshocksFR	numshocksBL	numshocksBR	distances	treadmeasureFL	treadmeasureFR	treadmeasureBL	treadmeasureBR
2	2024-01-01	0	0	0	0	0	0,00992	0,00992	0,00988	0,00993
3	2024-01-02	0	0	0	0	150	0,00991	0,00991	0,00987	0,00992

Data Preparation

- The excel file was imported into python.
- Data from 15 sheets (ID1 – ID30) combined into one dataset for the treated and untreated group.
- Missing thread values found using linear interpolation.
- Tread wear calculated as daily difference (treadmeasure_diff).
- Data cleaned (removed remaining NaN values).
- Created a new variable, ”**Average**” ; which is the mean of the thread measurements from all tyres.
- Added another variable “Treatment”, containing zeros and ones where 0 = Non – treatment group(Control group) and 1 = Treatment Group.

Data Preparation

Before data cleaning and processing:

day	umshocksF	umshocksF	umshocksB	umshocksB	distances	admeasure	admeasure	admeasure	admeasure
2024-06-21 00:00:00	0	0	0	0	452	0.00912	0.00912	0.00902	0.00907
2024-06-22 00:00:00	0	0	0	1	347	0.00909	0.00909	0.00899	0.00904
2024-06-23 00:00:00	0	0	1	0	34	0.00909	0.00909	0.00899	0.00904
2024-06-24 00:00:00	0	0	0	1	36	0.00909	0.00909	0.00899	0.00904
2024-06-25 00:00:00	0	0	0	0	102	0.00908	0.00908	0.00898	0.00903
2024-06-26 00:00:00	0	0	0	0	28	0.00908	0.00908	0.00898	0.00903
2024-06-27 00:00:00	0	0	0	0	230	0.00906	0.00906	0.00896	0.00901
2024-06-28 00:00:00	0	1	0	0	99	0.00905	0.00906	0.00895	0.009
2024-07-01 00:00:00	0	0	0	0	70	0.00904	0.00905	0.00894	0.00899
2024-07-02 00:00:00	0	0	0	0	77	0.00903	0.00904	0.00893	0.00898
2024-07-03 00:00:00	0	0	0	0	25	0.00903	0.00904	0.00893	0.00898
2024-07-05 00:00:00	0	0	0	0	86	0.00902	0.00903	0.00892	0.00897
2024-07-06 00:00:00	0	0	0	0	72	0.00901	0.00902	0.00891	0.00896

Data Preparation

After data preparation and cleaning:

treadmeasure_diff	distances	numshocks	treatment
0	0	0	1
1e-05	150	0	1
-0	45	0	1
-0	28	0	1
2e-05	192	0	1
1e-05	98	0	1
-0	14	0	1
-0	6	0	1
1e-05	92	0	1
-0	53	0	1
1e-05	89	0	1
2e-05	178	0	1
-0	8	0	1
2e-05	187	0	1
1e-05	66	0	1
-0	10	0	1

After data preparation and cleaning:

admeasure	admeasure	admeasure	admeasure	Treatment	Average
0.00982	0.00978	0.0099	0.00995	0	0.0098625
0.00982	0.00978	0.0099	0.00995	0	0.0098625
0.00982	0.00978	0.0099	0.00995	0	0.0098625
0.00979	0.00975	0.00987	0.00992	0	0.0098325
0.00979	0.00975	0.00987	0.00992	0	0.0098325
0.00977	0.00973	0.00985	0.0099	0	0.0098125
0.00977	0.00973	0.00985	0.0099	0	0.0098125
0.00976	0.00972	0.00984	0.00989	0	0.0098025
0.00976	0.00972	0.00984	0.00989	0	0.0098025
0.00975	0.00971	0.00983	0.00988	0	0.0097925

Research Question

- A new tyre durability treatment has been developed that claims that, with only one application of this "spray-on" treatment, the durability of the tyre is significantly increased. In short, do the treatment improve the durability of the tyres or not?

Linear Regression

STATISTICAL ANALYSIS

Statistical Analysis

- Linear regression:
  $\text{treadmeasure\_diff}_i = \beta_0 + \beta_1(distance)_i + \beta_2(numshocks)_i + \beta_3(treatment)_i + \in_i$
- Treatment coded: 1 = treated, 0 = untreated.
- Objective: Determine if treatment significantly affects tread wear.
- We conduct a robust linear regression to get the coefficients.

Regression Results

Linear Regression Results:

OLS Regression Results

Dep. Variable:	treadmeasure_diff	R-squared:	0.751
Model:	OLS	Adj. R-squared:	0.751
Method:	Least Squares	F-statistic:	2.064e+04
Date:	Sat, 18 Oct 2025	Prob (F-statistic):	0.00
Time:	22:32:22	Log-Likelihood:	2.2814e+05
No. Observations:	20492	AIC:	-4.563e+05
Df Residuals:	20488	BIC:	-4.562e+05
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	5.096e-07	4.45e-08	11.460	0.000	4.22e-07	5.97e-07
distances	9.577e-08	4.06e-10	235.927	0.000	9.5e-08	9.66e-08
numshocks	-2.24e-06	1.04e-07	-21.488	0.000	-2.44e-06	-2.04e-06
treatment	-3.61e-06	4.94e-08	-73.025	0.000	-3.71e-06	-3.51e-06

Omnibus:	2175.672	Durbin-Watson:	1.782
Prob(Omnibus):	0.000	Jarque-Bera (JB):	8296.494
Skew:	-0.494	Prob(JB):	0.00
Kurtosis:	5.956	Cond. No.	378.

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Distance coefficient: +9.58e-08, $p < 0.001$ ⟶ tread wear slightly increases with distance.

Number of shocks coefficient: -2.24e-06, $p < 0.001$ ⟶ negative which is unexpected.

Treatment coefficient: -3.61e-06, $p < 0.001$ ⟶ treated tyres wear less.

Model explains 75% of variation in tread wear ($R^2 = 0.751$)

Linear regression results interpretation

It can be concluded that:

- Treated tyres experience significantly less tread wear.
- Distance and shocks significantly affect tread wear.
- Treatment is effective in improving tyre durability.

Possible Takeaways:

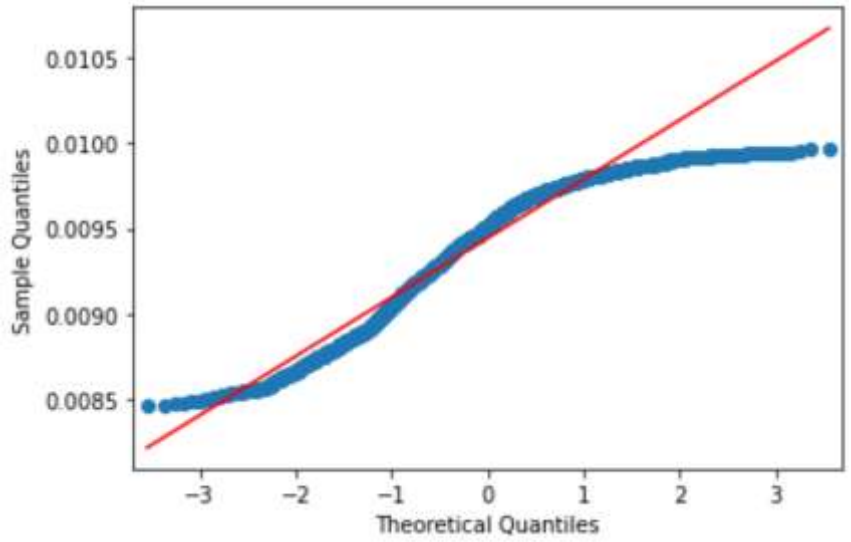
- Tyre treatment is effective in reducing tread wear
- Number of shocks has a negative coefficient, possibly because drivers slow down on rough roads
- Distance travelled contributes to wear but is less impactful
- Statistical analysis confirms the treatment's effectiveness

HYPOTHESIS TESTING

STATISTICAL ANALYSIS

Testing for normality

- Testing normality on the averages thread measure.
- Based on graphical test, by making use of qqplot, we found the following:



Testing normality

Interpretation of the graph:

The graph shows the average thread measure between the four tyres, is not normally distributed. Since the data does not follow the reference line.

Testing for normality

- Using of the Shapiro test to perform the formal test for normality.
- Hypothesis:

$$H_o: The\ data\ is\ normally\ distributed$$

$$VS$$

$$H_A: The\ data\ is\ not\ normally\ distributed$$

- Code:

```
#Shapiro test for normality:
tempM_new = (TreatmentTyres['Average']-np.mean(TreatmentTyres['Average']))/np.std(TreatmentTyres['Average'],ddof=1)
tempF_new = (NoTreatmentTyres['Average']-np.mean(NoTreatmentTyres['Average']))/np.std(NoTreatmentTyres['Average'],ddof=1)
poold = np.concatenate([tempM_new , tempM_new ])

shapiro(poold)
```

Testing for normality

- Results:

```
In [4]: shapiro(poold)
Out[4]: ShapiroResult(statistic=0.924559473991394, pvalue=7.006492321624085e-45)
```

Interpretation:

Since the $p - value < \alpha = 0.05$, we reject null hypothesis, and make a conclusion that the data is not normally distributed.

Testing For The Research Question

- Testing the following hypothesis:

$$H_o: \mu_{Treatment} = \mu_{No\_treatment}$$
$$VS$$
$$H_A: \mu_{Treatment} > \mu_{No\_treatment}$$

- Since the data is not normal, we make use of ranksums test(no-parametric test).

- Code:

```
ranksums(TreatmentTyres['Average'],NoTreatmentTyres['Average'],alternative="greater")
```

Testing For The Research Question

- Results:

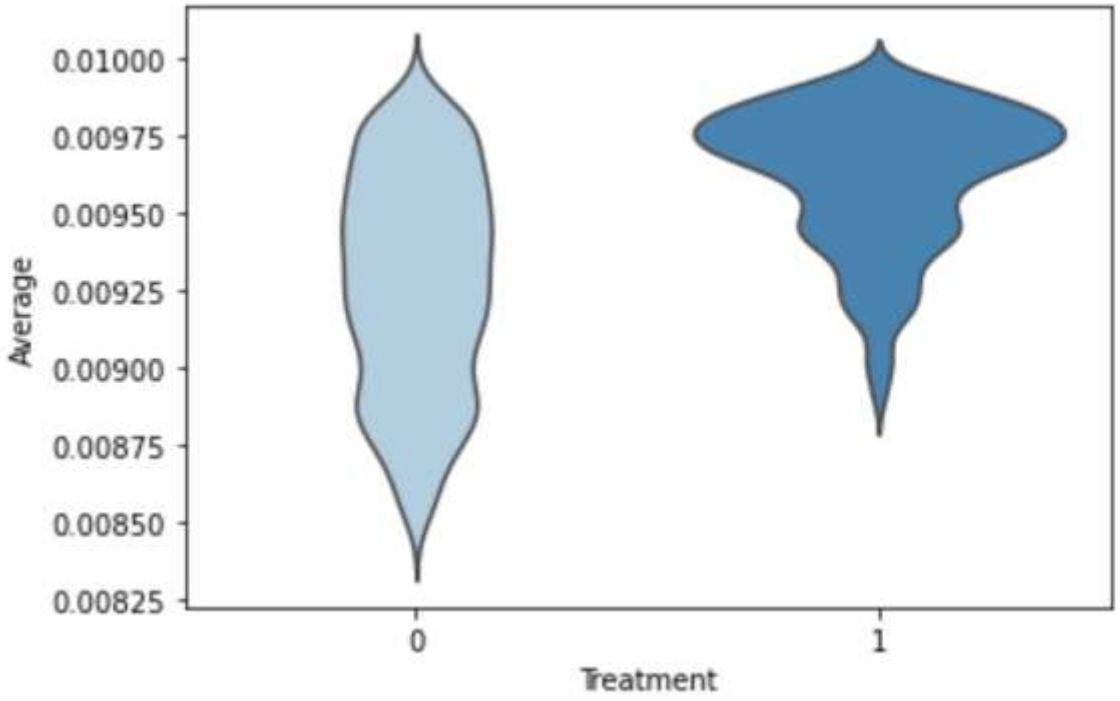
```
In [6]: ranksums(TreatmentTyres['Average'],NoTreatmentTyres['Average'],alternative="greater")
Out[6]: RanksumsResult(statistic=35.790999878734276, pvalue=7.622930314536839e-281)
```

Interpretation:

Since the $p - value < \alpha = 0.05$, we reject null hypothesis, and make a conclusion that the treatment improve the durability of the tyres

Testing For The Research Question

- According to violin plot we observe the following:



Testing For The Research Question

Interpretation:

The Violin plot shows that the treatment tyres have a higher and more consistent treat depth than the untreated tyres. This supports the hypothesis conclusion that the treatment significantly improves tyre durability.

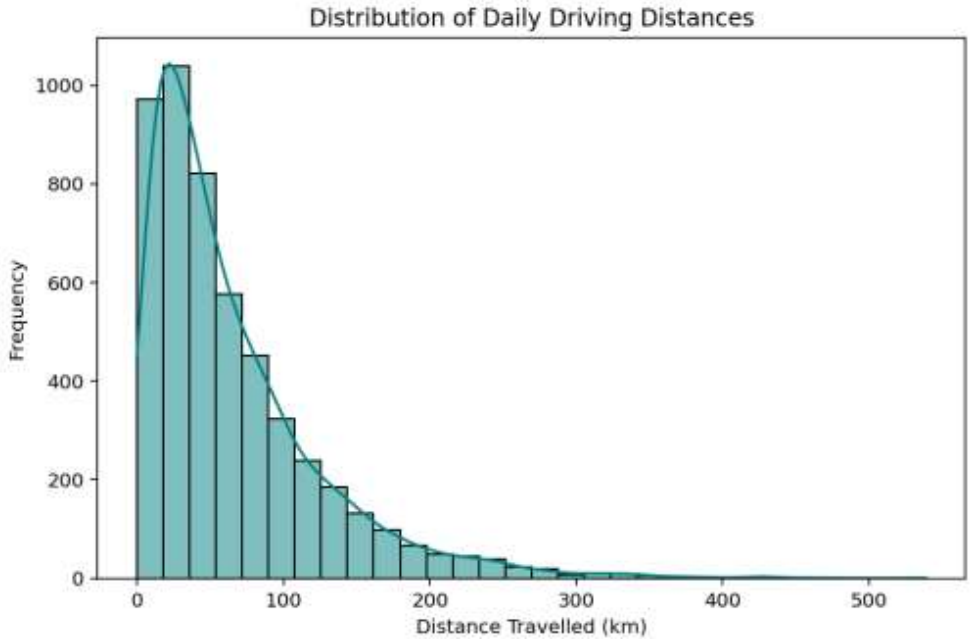
GRAPHICAL INTERPRETATION

DRIVING HABITS ANALYSIS

Driving Habits Analysis

- The aim of analysing the driving habit is to ensure that the driving behaviour didn't bias the tyre wear, making our investigation invalid or not reasonable.
- We performed the following analysis:
  - ✓Distance distribution per day (Using histogram).
  - ✓Average shock distribution per day (Using histogram).
  - ✓Comparison between driving distance and average shocks (Using scatterplot).
  - ✓Comparison of driving distance between treatment groups (Using boxplot).

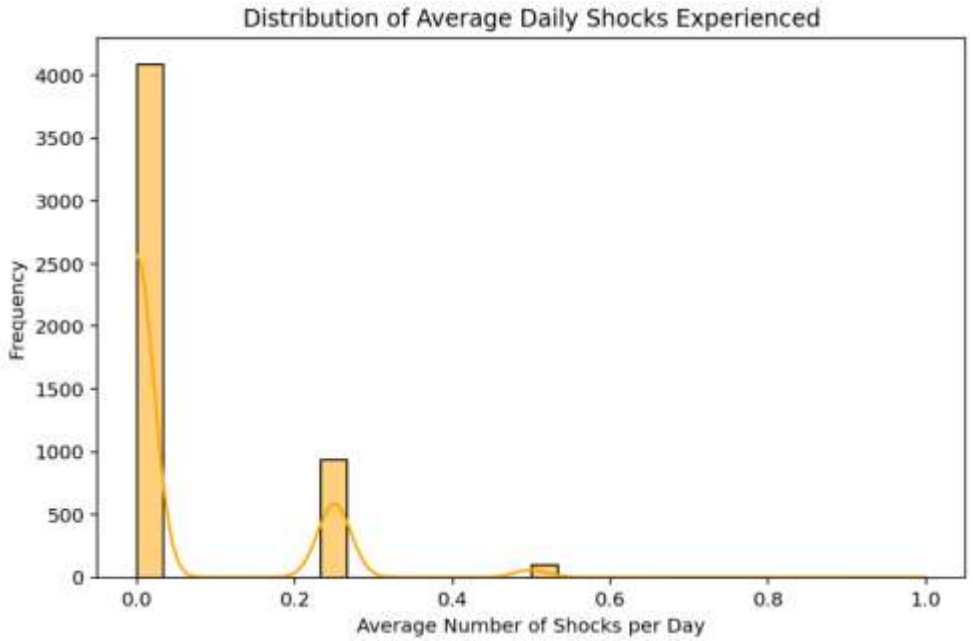
Distance distribution



Interpretation:

- Most employees travelled for a short distance of between (0-100) km, of which fewer travelled for a long distance of more than 100 km.
- From the histogram we can make an overall conclusion that, most employees they are responsible drivers.

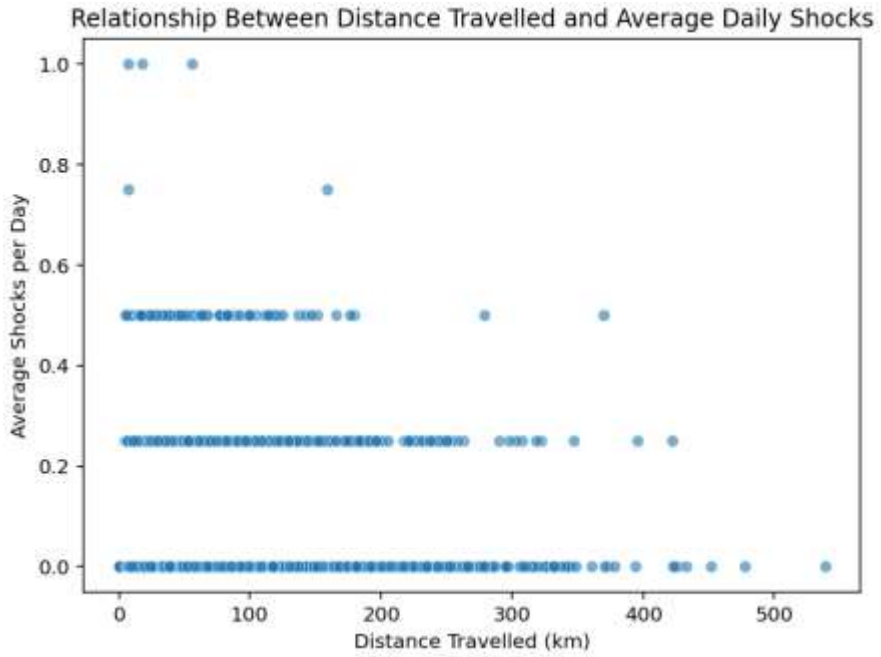
Average shock distribution



Interpretation:

- Most employees experienced few shocks per day.
- However, this suggests a smooth driving.
- There are fewer employees who experience on average large number of shocks and this can suggest that they where driving on rough routes and they were driving irresposebly.
- In an overall, most employees are responsible drivers.

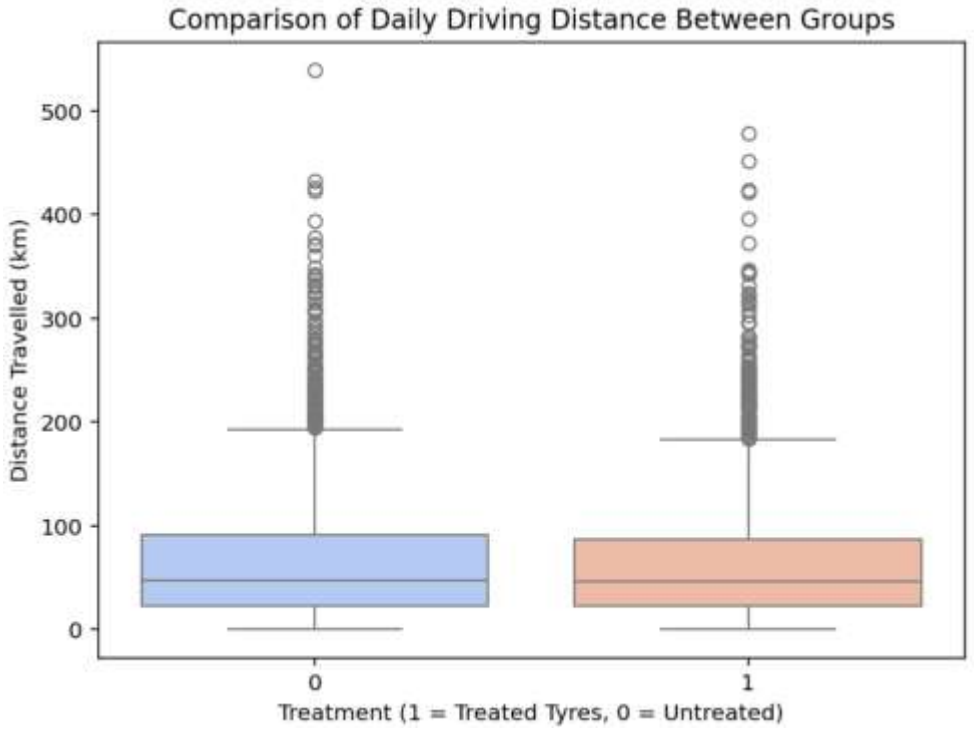
Comparison between driving distance and average shocks



Interpretation:

- The graphs shows a weak negative relationship between distance and average shocks per day.
- Employees who tend to drive longer , experience fewer shocks whereas those who drive for a short distance experience large number of shocks.

Comparison of driving distance between treatment groups



Interpretation:

- The boxplot shows that employees with treated and untreated tyres drove similar daily distances on average.
- This suggests that driving exposure was evenly distributed across participants, supporting the fairness of the experimental design.

Summary of driving habits

According to our graphical analysis, we can conclude that:

- Employees generally drove carefully and that they drove under similar road conditions.
- The driving distance was confirmed by the boxplot that is similar between the treated and the untreated group.
- This confirms that the difference in wear tyre was due to treatment not employee driving behaviour.

Overall Findings

Aspects	Results	Interpretation
Treatment effect	Significant	Treated tyres were more durable
Driving habits	Consistent	There's no major behavioural difference in driving between the employees.
Statistical Methods	Non-parametric (Wilcoxon).	Since the data was not normally distributed.

Overall Conclusion

- The "spray-on" tyre treatment greatly enhanced tyre life throughout the 8-month period.
- Employee driving behavior was balanced and equal between treated and untreated groups.
- So, the observed increases in tread depth can confidently be attributed to the treatment's effectiveness, and not to differences between driving conditions.