Business Case: Delhivery - Feature Engineering

Problem Statement : About Delhivery

Delhivery is the largest and fastest-growing fully integrated player in India by revenue in Fiscal 2021. They aim to build the operating system for commerce, through a combination of world-class infrastructure, logistics operations of the highest quality, and cutting-edge engineering and technology capabilities.

The Data team builds intelligence and capabilities using this data that helps them to widen the gap between the quality, efficiency, and profitability of their business versus their competitors.

Approach to understanding the problem and getting to insights

First we will understand the data we have received, and then check what possible operation we can do to analyse the data better and observe patterns to provide solutions.

Importing the relevant libraries

In [430…

```
import pandas as pd
import numpy as np
import matplotlib as plt
import seaborn as sns
pd.set_option('display.max_columns', None)
```

Loading CSV as Dataset

In [431…

```
df = pd.read_csv("/content/sample_data/delhivery_data.csv")
```

```
<ipython-input-431-483eed020ee8>:1: DtypeWarning: Columns (12) have mixed types. Specify dtype option on import or set low_memory=False.
  df = pd.read_csv("/content/sample_data/delhivery_data.csv")
```

Checking if the data is loaded as dataframe

In [432…

```
df.head()
```

Out[432…

	data	trip_creation_time	route_schedule_uuid	route_type	trip_uuid	source_center	source_name	destination_center	destination_nan
0	training	2018-09-20 02:35:36.476840	thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3...	Carting	trip-153741093647649320	IND388121AAA	Anand_VUNagar_DC (Gujarat)	IND388620AAB	Khambhat_MotvdDPP_ (Gujara
1	training	2018-09-20 02:35:36.476840	thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3...	Carting	trip-153741093647649320	IND388121AAA	Anand_VUNagar_DC (Gujarat)	IND388620AAB	Khambhat_MotvdDPP_ (Gujara

	data	trip_creation_time	route_schedule_uuid	route_type	trip_uuid	source_center	source_name	destination_center	destination_nan
2	training	2018-09-20 02:35:36.476840	thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3...	Carting	trip-153741093647649320	IND388121AAA	Anand_VUNagar_DC (Gujarat)	IND388620AAB	Khambhat_MotvdDPP_ (Gujara
3	training	2018-09-20 02:35:36.476840	thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3...	Carting	trip-153741093647649320	IND388121AAA	Anand_VUNagar_DC (Gujarat)	IND388620AAB	Khambhat_MotvdDPP_ (Gujara
4	training	2018-09-20 02:35:36.476840	thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3...	Carting	trip-153741093647649320	IND388121AAA	Anand_VUNagar_DC (Gujarat)	IND388620AAB	Khambhat_MotvdDPP_ (Gujara

Checking the shape of the data

In [433...

```
df.shape
```

Out[433...

```
(136557, 24)
```

Checking column name

In [434...

```
df.columns
```

Out[434...

```
Index(['data', 'trip_creation_time', 'route_schedule_uuid', 'route_type',
       'trip_uuid', 'source_center', 'source_name', 'destination_center',
       'destination_name', 'od_start_time', 'od_end_time',
       'start_scan_to_end_scan', 'is_cutoff', 'cutoff_factor',
       'cutoff_timestamp', 'actual_distance_to_destination', 'actual_time',
       'osrm_time', 'osrm_distance', 'factor', 'segment_actual_time',
       'segment_osrm_time', 'segment_osrm_distance', 'segment_factor'],
      dtype='object')
```

OBSERVATION: This data consists of 136557 checkpoints described across 24 columns.

Checking data type of each column

In [435...

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 136557 entries, 0 to 136556
Data columns (total 24 columns):
 #   Column                          Non-Null Count   Dtype
---  ------                          --------------   -----
 0   data                            136557 non-null  object
 1   trip_creation_time              136557 non-null  object
 2   route_schedule_uuid             136557 non-null  object
 3   route_type                      136557 non-null  object
 4   trip_uuid                       136557 non-null  object
 5   source_center                   136557 non-null  object
 6   source_name                     136285 non-null  object
 7   destination_center              136557 non-null  object
 8   destination_name                136329 non-null  object
 9   od_start_time                   136556 non-null  object
 10  od_end_time                     136556 non-null  object
 11  start_scan_to_end_scan          136556 non-null  float64
 12  is_cutoff                       136556 non-null  object
 13  cutoff_factor                   136556 non-null  float64
 14  cutoff_timestamp                136556 non-null  object
 15  actual_distance_to_destination  136556 non-null  float64
 16  actual_time                     136556 non-null  float64
 17  osrm_time                       136556 non-null  float64
 18  osrm_distance                   136556 non-null  float64
 19  factor                          136556 non-null  float64
 20  segment_actual_time             136556 non-null  float64
 21  segment_osrm_time               136556 non-null  float64
 22  segment_osrm_distance           136556 non-null  float64
 23  segment_factor                  136556 non-null  float64
dtypes: float64(11), object(13)
memory usage: 25.0+ MB
```

OBSERVATION: The time column should be of correct datatype, that is: datetime

Convert the od_start_time and od_end_time to datetime data type

In [436...

```
df["trip_creation_time"] = pd.to_datetime(df["trip_creation_time"])
df["od_start_time"] = pd.to_datetime(df["od_start_time"])
df["od_end_time"] = pd.to_datetime(df["od_end_time"])
```

In [437...

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 136557 entries, 0 to 136556
Data columns (total 24 columns):
 #   Column                          Non-Null Count   Dtype
---  ------                          --------------   -----
 0   data                            136557 non-null  object
 1   trip_creation_time              136557 non-null  datetime64[ns]
 2   route_schedule_uuid             136557 non-null  object
 3   route_type                      136557 non-null  object
 4   trip_uuid                       136557 non-null  object
 5   source_center                   136557 non-null  object
 6   source_name                     136285 non-null  object
 7   destination_center              136557 non-null  object
 8   destination_name                136329 non-null  object
 9   od_start_time                   136556 non-null  datetime64[ns]
 10  od_end_time                     136556 non-null  datetime64[ns]
 11  start_scan_to_end_scan          136556 non-null  float64
 12  is_cutoff                       136556 non-null  object
 13  cutoff_factor                   136556 non-null  float64
 14  cutoff_timestamp                136556 non-null  object
 15  actual_distance_to_destination  136556 non-null  float64
 16  actual_time                     136556 non-null  float64
 17  osrm_time                       136556 non-null  float64
 18  osrm_distance                   136556 non-null  float64
 19  factor                          136556 non-null  float64
 20  segment_actual_time             136556 non-null  float64
 21  segment_osrm_time               136556 non-null  float64
 22  segment_osrm_distance           136556 non-null  float64
 23  segment_factor                  136556 non-null  float64
dtypes: datetime64[ns](3), float64(11), object(10)
memory usage: 25.0+ MB
```

Checking for missing vaules in column

In [438…

```
df.isnull().sum()
```

Out[438…

	0
data	0
trip_creation_time	0
route_schedule_uuid	0
route_type	0
trip_uuid	0
source_center	0
source_name	272
destination_center	0
destination_name	228
od_start_time	1
od_end_time	1
start_scan_to_end_scan	1
is_cutoff	1
cutoff_factor	1
cutoff_timestamp	1
actual_distance_to_destination	1
actual_time	1
osrm_time	1
osrm_distance	1

	0
factor	1
segment_actual_time	1
segment_osrm_time	1
segment_osrm_distance	1
segment_factor	1

dtype: int64

OBSERVATION: There are missing values in columns: source_name, destination_name, and segment factor. Since the missing values are less than 1% of the total data, we can directly drop the NULL values.

Dropping the NULL values from the dataset

In [439…

```
df = df.dropna(how ='any')
```

Checking the shape of data after dropping NULL Values

In [440…

```
df.shape
```

Out[440…

```
(136059, 24)
```

OBSERVATION: The new dataset is decreased by less than 1% of the actual raw dataset. This is acceptable for further Data Analysis.

In [441…

```
df_null_check = df.isnull().sum()
```

Checking to see if there are any NULL values in the new dataset.

In [442…

```
df_null_check
```

Out[442…

	0
data	0
trip_creation_time	0
route_schedule_uuid	0
route_type	0
trip_uuid	0
source_center	0

	0
source_name	0
destination_center	0
destination_name	0
od_start_time	0
od_end_time	0
start_scan_to_end_scan	0
is_cutoff	0
cutoff_factor	0
cutoff_timestamp	0
actual_distance_to_destination	0
actual_time	0
osrm_time	0
osrm_distance	0
factor	0
segment_actual_time	0
segment_osrm_time	0
segment_osrm_distance	0
segment_factor	0

dtype: int64

OBSERVATION: No NULL values in the new dataset.

Checking the statistical summary of raw data

In [443…

```
df.describe()
```

Out[443…

	trip_creation_time	od_start_time	od_end_time	start_scan_to_end_scan	cutoff_factor	actual_distance_to_destination	actual_time	osrm_tim
count	136059	136059	136059	136059.000000	136059.000000	136059.000000	136059.000000	136059.00000
mean	2018-09-22 12:37:09.315812352	2018-09-22 17:02:24.815698432	2018-09-23 09:14:34.558658816	971.666520	235.486304	236.630012	421.868241	216.10698

	trip_creation_time	od_start_time	od_end_time	start_scan_to_end_scan	cutoff_factor	actual_distance_to_destination	actual_time	osrm_tim
min	2018-09-12 00:00:16.535741	2018-09-12 00:00:16.535741	2018-09-12 00:50:10.814399	20.000000	9.000000	9.000055	9.000000	6.00000
25%	2018-09-17 02:21:59.831977984	2018-09-17 06:26:04.219940096	2018-09-18 01:02:03.127152896	162.000000	22.000000	23.386336	52.000000	27.00000
50%	2018-09-22 02:14:33.861478912	2018-09-22 06:18:11.753445888	2018-09-23 02:08:09.761019904	456.000000	66.000000	66.217249	133.000000	65.00000
75%	2018-09-27 17:53:19.027942912	2018-09-27 22:05:12.999181056	2018-09-28 12:13:41.675546112	1673.000000	286.000000	287.854860	525.000000	265.00000
max	2018-10-03 23:59:42.701692	2018-10-06 00:08:33.866586	2018-10-08 03:00:24.353479	7898.000000	1927.000000	1927.447705	4532.000000	1686.00000
std	NaN	NaN	NaN	1042.379854	346.228069	346.454324	602.208577	309.26424

Checking if any orders are returned to source location.

In [444...

```
returned_orders = df.groupby("trip_uuid").apply(lambda group: pd.DataFrame({"Returned_Packages": [any(group["source_center"] == group["d
returned_orders.head()
```

```
<ipython-input-444-887a70d66ffd>:1: DeprecationWarning: DataFrameGroupBy.apply operated on the grouping columns. This behavior is deprec
ated, and in a future version of pandas the grouping columns will be excluded from the operation. Either pass `include_groups=False` to
exclude the groupings or explicitly select the grouping columns after groupby to silence this warning.
  returned_orders = df.groupby("trip_uuid").apply(lambda group: pd.DataFrame({"Returned_Packages": [any(group["source_center"] == group
["destination_center"])]})).reset_index()
```

Out[444...

	trip_uuid	level_1	Returned_Packages
0	trip-153671041653548748	0	False
1	trip-153671042288605164	0	False
2	trip-153671043369099517	0	False
3	trip-153671046011330457	0	False
4	trip-153671052974046625	0	False

In [445...

```
true_instances = returned_orders[returned_orders['Returned_Packages'] == True].index.tolist()
true_instances
```

Out[445...

```
[]
```

OBSERVATION: The below shows if any values are TRUE for Returned_Packages. Since the returned list is empty, it means no packages were returned.

The current details are split for different trips as per different check-points for that trips. Data can be analysed better if the times of each check-points can be summed up for each trip ID.

In [446…

```
df_combined_times = df.groupby("trip_uuid")[["segment_actual_time", "segment_osrm_time", "segment_osrm_distance"]].sum()
df_combined_times["segment_osrm_distance"] = np.round(df_combined_times["segment_osrm_distance"], 2)
df_combined_times = df_combined_times.rename(columns = {"segment_osrm_time" : "accumulated_osrm_time", "segment_actual_time" : "accumula
df_combined_times.head()
```

Out[446…

	accumulated_actual_time	accumulated_osrm_time	accumulated_osrm_distance
trip_uuid			
trip-153671041653548748	1548.0	1008.0	1320.47
trip-153671042288605164	141.0	65.0	84.19
trip-153671043369099517	3308.0	1941.0	2545.27
trip-153671046011330457	59.0	16.0	19.88
trip-153671052974046625	340.0	115.0	146.79

In [447…

```
df_combined_times_1 = df.groupby(["trip_uuid","destination_center"])[["actual_time", "osrm_time", "osrm_distance"]].last()
df_combined_times_1 = df_combined_times_1.reset_index()
df_combined_times_1 = df_combined_times_1.groupby("trip_uuid")[["actual_time", "osrm_time", "osrm_distance"]].sum()
df_combined_times_1.head()
```

Out[447…

	actual_time	osrm_time	osrm_distance
trip_uuid			
trip-153671041653548748	1562.0	717.0	991.3523
trip-153671042288605164	143.0	68.0	85.1110
trip-153671043369099517	3347.0	1740.0	2354.0665
trip-153671046011330457	59.0	15.0	19.6800
trip-153671052974046625	341.0	117.0	146.7918

Calculation of time difference between OSRM time and Actual Time to know how much time error present present in the OSRM time calculation.

In [448…

```
df_combined_times_1 = df_combined_times_1.reset_index()
df_combined_times = pd.merge(df_combined_times, df_combined_times_1, on = "trip_uuid")
df_combined_times.head()
```

Out[448…

	trip_uuid	accumulated_actual_time	accumulated_osrm_time	accumulated_osrm_distance	actual_time	osrm_time	osrm_distance
0	trip-153671041653548748	1548.0	1008.0	1320.47	1562.0	717.0	991.3523
1	trip-153671042288605164	141.0	65.0	84.19	143.0	68.0	85.1110
2	trip-153671043369099517	3308.0	1941.0	2545.27	3347.0	1740.0	2354.0665
3	trip-153671046011330457	59.0	16.0	19.88	59.0	15.0	19.6800
4	trip-153671052974046625	340.0	115.0	146.79	341.0	117.0	146.7918

Creating a dataframe with custom names and necessary features to analyse data in a better way.

In [449…

```
od_start_time = df.groupby('trip_uuid')['od_start_time'].first()
od_start_time = od_start_time.reset_index()
od_start_time = od_start_time.rename(columns={'od_start_time': 'trip_start_time'})
df_combined_times = df_combined_times.merge(od_start_time, on='trip_uuid', how='left').reset_index(drop=True)
df_combined_times["trip_start_date"] = df_combined_times["trip_start_time"].dt.date
trip_start_location = df.groupby('trip_uuid')['source_name'].first()
trip_end_location = df.groupby('trip_uuid')['destination_name'].last()
trip_end_location = trip_end_location.reset_index()
trip_start_location = trip_start_location.reset_index()
df_combined_times = df_combined_times.merge(trip_start_location, on='trip_uuid', how='left').reset_index(drop=True)
df_combined_times = df_combined_times.merge(trip_end_location, on='trip_uuid', how='left').reset_index(drop=True)
df_combined_times = df_combined_times.drop(columns=['trip_start_time'])
df_combined_times.head()
```

Out[449…

	trip_uuid	accumulated_actual_time	accumulated_osrm_time	accumulated_osrm_distance	actual_time	osrm_time	osrm_distance	trip_start_date	
0	trip-153671041653548748	1548.0	1008.0	1320.47	1562.0	717.0	991.3523	2018-09-12	E
1	trip-153671042288605164	141.0	65.0	84.19	143.0	68.0	85.1110	2018-09-12	T
2	trip-153671043369099517	3308.0	1941.0	2545.27	3347.0	1740.0	2354.0665	2018-09-12	Bang
3	trip-153671046011330457	59.0	16.0	19.88	59.0	15.0	19.6800	2018-09-12	
4	trip-153671052974046625	340.0	115.0	146.79	341.0	117.0	146.7918	2018-09-12	Bell

In [450…

```
od_start_time = df.groupby('trip_uuid')['od_start_time'].first()
od_start_time = od_start_time.reset_index()
od_start_time = od_start_time.rename(columns={'od_start_time': 'trip_start_time'})
```

```
df_combined_times = df_combined_times.merge(od_start_time, on='trip_uuid', how='left').reset_index(drop=True)
df_combined_times.head()
```

Out[450…

	trip_uuid	accumulated_actual_time	accumulated_osrm_time	accumulated_osrm_distance	actual_time	osrm_time	osrm_distance	trip_start_date	
0	trip-153671041653548748	1548.0	1008.0	1320.47	1562.0	717.0	991.3523	2018-09-12	E
1	trip-153671042288605164	141.0	65.0	84.19	143.0	68.0	85.1110	2018-09-12	-
2	trip-153671043369099517	3308.0	1941.0	2545.27	3347.0	1740.0	2354.0665	2018-09-12	Bang
3	trip-153671046011330457	59.0	16.0	19.88	59.0	15.0	19.6800	2018-09-12	
4	trip-153671052974046625	340.0	115.0	146.79	341.0	117.0	146.7918	2018-09-12	Bella

Creating a column for Starting Point and Ending Point of a trip using States names

In [451…

```
df_combined_times["source_name"] = df_combined_times["source_name"].str.split("(").str[1]
df_combined_times["source_name"] = df_combined_times["source_name"].str.split(")").str[0]
df_combined_times["source_name"] = df_combined_times["source_name"].apply(lambda x : x.upper())
df_combined_times["destination_name"] = df_combined_times["destination_name"].str.split("(").str[1]
df_combined_times["destination_name"] = df_combined_times["destination_name"].str.split(")").str[0]
df_combined_times["destination_name"] = df_combined_times["destination_name"].apply(lambda x : x.upper())
df_combined_times.head()
```

Out[451…

	trip_uuid	accumulated_actual_time	accumulated_osrm_time	accumulated_osrm_distance	actual_time	osrm_time	osrm_distance	trip_start_date	so
0	trip-153671041653548748	1548.0	1008.0	1320.47	1562.0	717.0	991.3523	2018-09-12	
1	trip-153671042288605164	141.0	65.0	84.19	143.0	68.0	85.1110	2018-09-12	K
2	trip-153671043369099517	3308.0	1941.0	2545.27	3347.0	1740.0	2354.0665	2018-09-12	K
3	trip-153671046011330457	59.0	16.0	19.88	59.0	15.0	19.6800	2018-09-12	MAH
4	trip-153671052974046625	340.0	115.0	146.79	341.0	117.0	146.7918	2018-09-12	K

In [452…

```
od_start = df.groupby('trip_uuid')['od_start_time'].first()
od_end = df.groupby('trip_uuid')['od_end_time'].last()
df_combined_times = df_combined_times.set_index('trip_uuid').merge(od_start, left_index=True, right_index=True).reset_index()
df_combined_times = df_combined_times.set_index('trip_uuid').merge(od_end, left_index=True, right_index=True).reset_index()
df_combined_times["trip_duration"] = (df_combined_times["od_end_time"] - df_combined_times["od_start_time"]).dt.total_seconds()/60
df_combined_times.head()
```

Out[452…

	trip_uuid	accumulated_actual_time	accumulated_osrm_time	accumulated_osrm_distance	actual_time	osrm_time	osrm_distance	trip_start_date	so
0	trip-153671041653548748	1548.0	1008.0	1320.47	1562.0	717.0	991.3523	2018-09-12	
1	trip-153671042288605164	141.0	65.0	84.19	143.0	68.0	85.1110	2018-09-12	K
2	trip-153671043369099517	3308.0	1941.0	2545.27	3347.0	1740.0	2354.0665	2018-09-12	K
3	trip-153671046011330457	59.0	16.0	19.88	59.0	15.0	19.6800	2018-09-12	MAH
4	trip-153671052974046625	340.0	115.0	146.79	341.0	117.0	146.7918	2018-09-12	K

In [453…

```
df_start_t_to_end_t = df.groupby("trip_uuid")[["start_scan_to_end_scan","actual_distance_to_destination"]].last()
df_start_t_to_end_t = df_start_t_to_end_t.reset_index()
df_combined_times = df_combined_times.merge(df_start_t_to_end_t, on = "trip_uuid")
df_combined_times.head()
```

Out[453…

	trip_uuid	accumulated_actual_time	accumulated_osrm_time	accumulated_osrm_distance	actual_time	osrm_time	osrm_distance	trip_start_date	so
0	trip-153671041653548748	1548.0	1008.0	1320.47	1562.0	717.0	991.3523	2018-09-12	
1	trip-153671042288605164	141.0	65.0	84.19	143.0	68.0	85.1110	2018-09-12	K
2	trip-153671043369099517	3308.0	1941.0	2545.27	3347.0	1740.0	2354.0665	2018-09-12	K
3	trip-153671046011330457	59.0	16.0	19.88	59.0	15.0	19.6800	2018-09-12	MAH
4	trip-153671052974046625	340.0	115.0	146.79	341.0	117.0	146.7918	2018-09-12	K

In [454…

```
df_route_type = df.groupby("trip_uuid")["route_type"].first()
df_route_type.reset_index()
df_combined_times = df_combined_times.merge(df_route_type, on = "trip_uuid")
df_combined_times.head()
```

Out[454…

	trip_uuid	accumulated_actual_time	accumulated_osrm_time	accumulated_osrm_distance	actual_time	osrm_time	osrm_distance	trip_start_date	so
0	trip-153671041653548748	1548.0	1008.0	1320.47	1562.0	717.0	991.3523	2018-09-12	
1	trip-153671042288605164	141.0	65.0	84.19	143.0	68.0	85.1110	2018-09-12	K
2	trip-153671043369099517	3308.0	1941.0	2545.27	3347.0	1740.0	2354.0665	2018-09-12	K
3	trip-153671046011330457	59.0	16.0	19.88	59.0	15.0	19.6800	2018-09-12	MAH
4	trip-153671052974046625	340.0	115.0	146.79	341.0	117.0	146.7918	2018-09-12	K

Organising the columns in a better way

In [455…

```
df_combined_times.describe()
```

Out[455…

	accumulated_actual_time	accumulated_osrm_time	accumulated_osrm_distance	actual_time	osrm_time	osrm_distance	trip_start_time	od_start_t
count	13886.000000	13886.000000	13886.000000	13886.000000	13886.000000	13886.000000	13886	13
mean	354.517068	181.261270	223.717758	357.224471	161.361011	204.427524	2018-09-22 13:11:41.328608768	2018-09 13:11:41.328608
min	9.000000	6.000000	9.070000	9.000000	6.000000	9.072900	2018-09-12 00:00:16.535741	2018-09 00:00:16.535
25%	66.000000	30.000000	32.540000	67.000000	29.000000	30.715050	2018-09-17 03:49:13.747945728	2018-09 03:49:13.747945
50%	147.000000	65.000000	69.890000	148.500000	60.000000	65.279050	2018-09-22 03:44:51.733427968	2018-09 03:44:51.733427
75%	364.000000	184.000000	217.410000	367.000000	168.000000	206.312975	2018-09-27 19:52:50.196828928	2018-09 19:52:50.196828
max	6230.000000	2564.000000	3523.630000	6265.000000	2032.000000	2840.081000	2018-10-04 20:15:07.233819	2018-10 20:15:07.233
std	558.675986	315.760533	418.230841	563.367162	272.139846	371.500357	NaN	

In [456…

```
df_combined_times = df_combined_times.loc[:, ['trip_uuid', 'route_type', 'source_name', 'trip_start_date', 'destination_name', 'od_end_t
df_combined_times["od_end_time"] = df_combined_times["od_end_time"].dt.date
df_combined_times = df_combined_times.rename(columns = {"od_end_time" : "trip_end_date"})
df_combined_times.head()
```

Out[456…

	trip_uuid	route_type	source_name	trip_start_date	destination_name	trip_end_date	trip_duration	actual_distance_to_destination	start_scan_to_end
0	trip-153671041653548748	FTL	MADHYA PRADESH	2018-09-12	HARYANA	2018-09-13	2260.109800	383.759164	
1	trip-153671042288605164	Carting	KARNATAKA	2018-09-12	KARNATAKA	2018-09-12	181.611874	24.644021	
2	trip-153671043369099517	FTL	KARNATAKA	2018-09-12	PUNJAB	2018-09-14	3934.362520	237.439610	
3	trip-153671046011330457	Carting	MAHARASHTRA	2018-09-12	MAHARASHTRA	2018-09-12	100.494935	17.175274	
4	trip-153671052974046625	FTL	KARNATAKA	2018-09-12	KARNATAKA	2018-09-12	718.349042	41.317614	

Checking which day was most busy in the data.

In [457…

```
most_busy_days = df_combined_times['trip_start_date'].value_counts().sort_index()
most_busy_days
```

Out[457…

	count
trip_start_date	
2018-09-12	647
2018-09-13	689
2018-09-14	662
2018-09-15	775
2018-09-16	570
2018-09-17	672
2018-09-18	743
2018-09-19	641
2018-09-20	675

	count
trip_start_date	
2018-09-21	681
2018-09-22	705
2018-09-23	575
2018-09-24	607
2018-09-25	646
2018-09-26	656
2018-09-27	606
2018-09-28	575
2018-09-29	569
2018-09-30	480
2018-10-01	560
2018-10-02	510
2018-10-03	593
2018-10-04	49

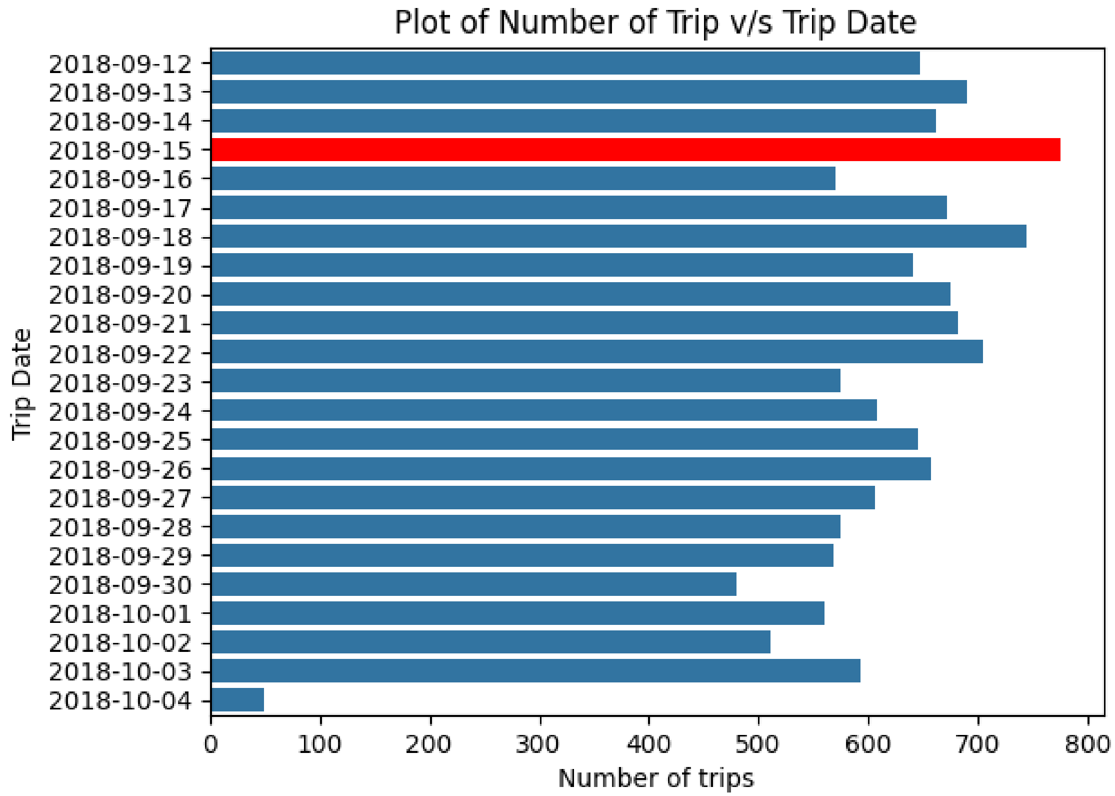
dtype: int64

In [458…

```python
most_busy_days = df_combined_times['trip_start_date'].value_counts().sort_index().reset_index()
most_busy_day = sns.barplot(data = most_busy_days, x = "count", y = "trip_start_date")
bars = most_busy_day.patches
bars[3].set_facecolor("red")
# bars[6].set_facecolor("orange")
# bars[10].set_facecolor("green")
most_busy_day.set(xlabel ="Number of trips", ylabel = "Trip Date", title ='Plot of Number of Trip v/s Trip Date')
```

Out[458…

```
[Text(0.5, 0, 'Number of trips'),
 Text(0, 0.5, 'Trip Date'),
 Text(0.5, 1.0, 'Plot of Number of Trip v/s Trip Date')]
```



OBSERVATION : 15th September, 2018 had the most number of trips - 775 trips.

Checking which State handles most trips.

In [459…

```
df_top_10_city = df_combined_times["source_name"].value_counts().head(10)

df_top_10_destination_name = df_combined_times["destination_name"].value_counts().head(10)

df_most_busy_city = df_top_10_city.reset_index().merge(df_top_10_destination_name.reset_index(), left_on="source_name", right_on="destin

df_most_busy_city = df_most_busy_city.rename(columns={"source_name": "city_name"})

df_most_busy_city = df_most_busy_city.drop(columns=["destination_name"])

df_most_busy_city = df_most_busy_city.rename(columns = {"count_x" : "from_state", "count_y" : "to_state"})

df_most_busy_city
```

Out[459…

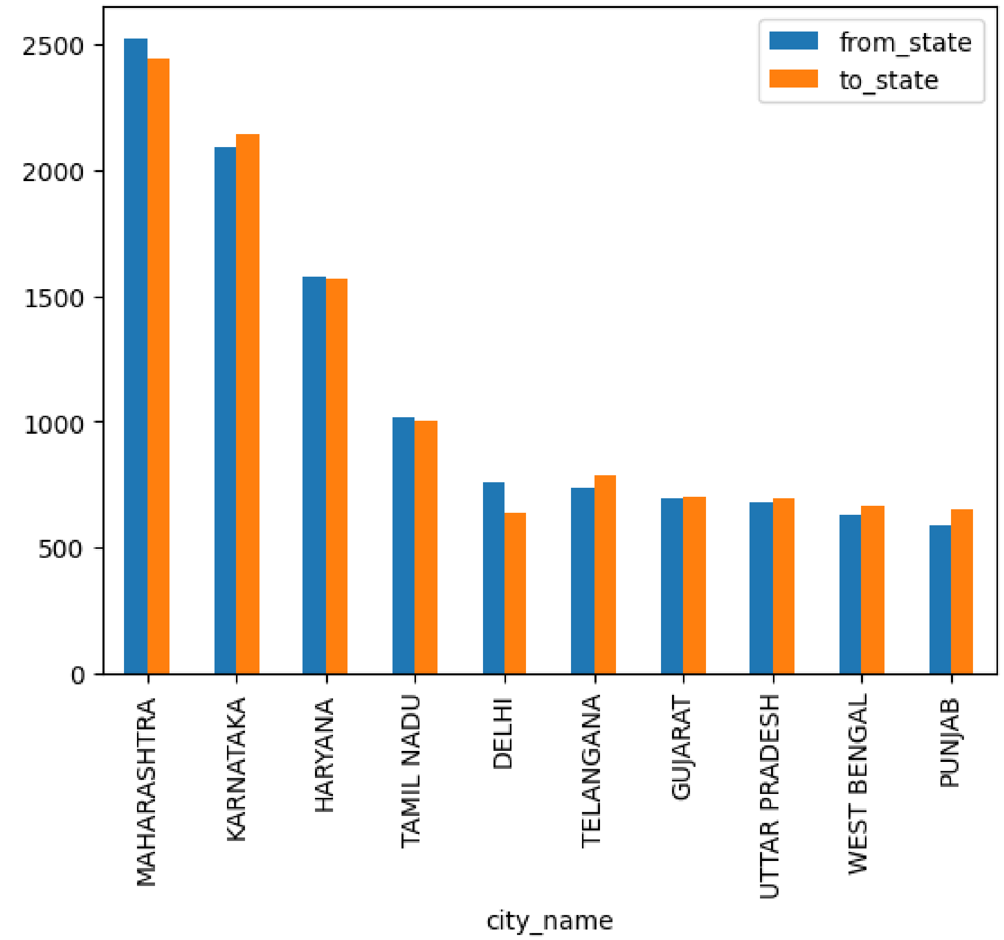
	city_name	from_state	to_state
0	MAHARASHTRA	2524	2440
1	KARNATAKA	2089	2144
2	HARYANA	1574	1568
3	TAMIL NADU	1018	1004
4	DELHI	756	635
5	TELANGANA	733	789
6	GUJARAT	692	704
7	UTTAR PRADESH	677	692
8	WEST BENGAL	632	667
9	PUNJAB	587	647

In [460…

```
df_most_busy_city.plot(x = "city_name", y=["from_state", "to_state"], kind="bar")
```

Out[460…

```
<Axes: xlabel='city_name'>
```



OBSERVATION : Maharashtra is the busiest state handling 2682 trips as source_center and 2591 trips as destination_center. It is followed by Karnataka and Haryana.

In [461…

```
df_bottom_10_city = df_combined_times["source_name"].value_counts().tail(13)

df_bottom_10_destination_name = df_combined_times["destination_name"].value_counts().tail(13)

df_least_busy_city = df_bottom_10_city.reset_index().merge(df_bottom_10_destination_name.reset_index(), left_on="source_name", right_on=

df_least_busy_city = df_least_busy_city.rename(columns={"source_name": "city_name"})

df_least_busy_city = df_least_busy_city.drop(columns=["destination_name"])

df_least_busy_city = df_least_busy_city.rename(columns = {"count_x" : "from_state", "count_y" : "to_state"})
```

Out[461…

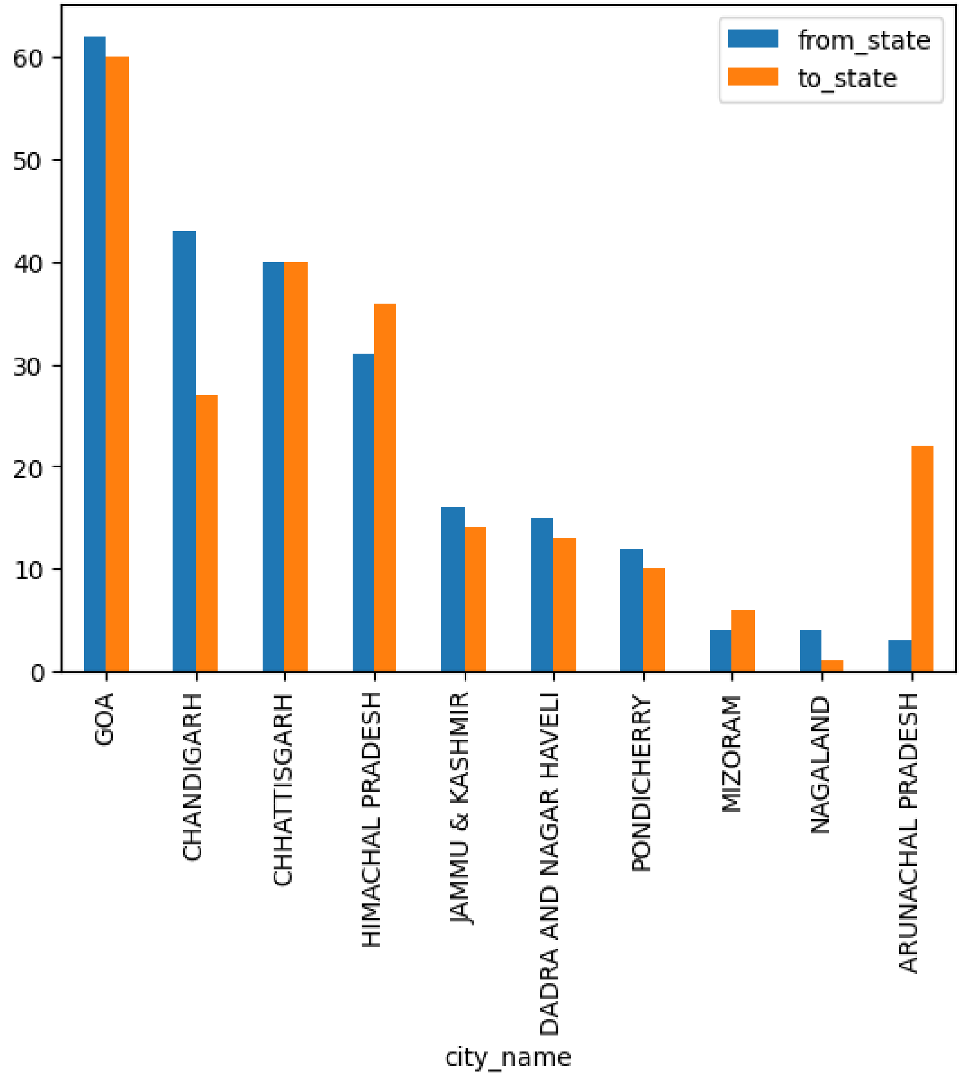
	city_name	from_state	to_state
0	GOA	62	60
1	CHANDIGARH	43	27
2	CHHATTISGARH	40	40
3	HIMACHAL PRADESH	31	36
4	JAMMU & KASHMIR	16	14
5	DADRA AND NAGAR HAVELI	15	13
6	PONDICHERRY	12	10
7	MIZORAM	4	6
8	NAGALAND	4	1
9	ARUNACHAL PRADESH	3	22

In [462…

```
df_least_busy_city.plot(x = "city_name", y=["from_state", "to_state"], kind="bar")
```

Out[462…

```
<Axes: xlabel='city_name'>
```



OBSERVATION : Nagaland is the least busiest state handling 5 trips as source_center and 1 trips as destination_center. It is followed by Mizoram.

Checking busiest inter-state corridor

In [463…

```
busy_corridor =  df_combined_times[df_combined_times["source_name"] != df_combined_times["destination_name"]]

busiest_corridor_trip_count = busy_corridor.groupby(["source_name", "destination_name"])["trip_uuid"].count().sort_values(ascending=Fals
busiest_corridor_trip_count = busiest_corridor.reset_index()
busiest_corridor.head()
```

Out[463…

	source_name	destination_name	trip_uuid
0	DELHI	HARYANA	378
1	HARYANA	DELHI	294
2	DELHI	UTTAR PRADESH	90
3	HARYANA	UTTAR PRADESH	88
4	HARYANA	PUNJAB	78

In [464…

```
busy_corridor
```

Out[464…

	trip_uuid	route_type	source_name	trip_start_date	destination_name	trip_end_date	trip_duration	actual_distance_to_destination	start_scan_t
0	trip-153671041653548748	FTL	MADHYA PRADESH	2018-09-12	HARYANA	2018-09-13	2260.109800	383.759164	
2	trip-153671043369099517	FTL	KARNATAKA	2018-09-12	PUNJAB	2018-09-14	3934.362520	237.439610	
12	trip-153671121411074590	FTL	TELANGANA	2018-09-12	KARNATAKA	2018-09-12	996.217031	177.510885	
15	trip-153671143043841452	FTL	UTTAR PRADESH	2018-09-12	MADHYA PRADESH	2018-09-12	514.616477	129.749996	
33	trip-153671320412492075	FTL	KARNATAKA	2018-09-12	TELANGANA	2018-09-12	916.941170	163.989437	
...	...	...	...	...	...	...	...	...	
13817	trip-153860641799000683	Carting	DELHI	2018-10-03	HARYANA	2018-10-04	238.373830	40.489470	
13822	trip-153860698042160875	FTL	MAHARASHTRA	2018-10-03	PUNJAB	2018-10-05	2661.132086	173.510827	
13824	trip-153860723585992237	FTL	KARNATAKA	2018-10-03	TELANGANA	2018-10-04	781.643506	96.160037	
13831	trip-153860787916550213	Carting	DELHI	2018-10-03	HARYANA	2018-10-04	128.067879	45.977014	
13864	trip-153861014185597051	FTL	MADHYA PRADESH	2018-10-03	HARYANA	2018-10-05	2182.120429	267.020528	

2857 rows × 15 columns

In [465…

```
busiest_corridor_avg_time = busy_corridor.groupby(["source_name", "destination_name"])["actual_time"].mean().sort_values(ascending=False
busiest_corridor_avg_time = busiest_corridor_avg_time.reset_index()
busiest_corridor_avg_time
```

Out[465…

	source_name	destination_name	actual_time
0	ASSAM	MAHARASHTRA	5457.000000
1	MAHARASHTRA	ASSAM	5067.000000
2	TAMIL NADU	HARYANA	3606.000000
3	KARNATAKA	PUNJAB	3376.562500
4	PUNJAB	KARNATAKA	3374.666667
...	...	...	...
125	UTTAR PRADESH	RAJASTHAN	92.333333
126	PUNJAB	CHANDIGARH	69.538462
127	DADRA AND NAGAR HAVELI	GUJARAT	48.333333
128	GUJARAT	DAMAN & DIU	43.000000
129	GUJARAT	DADRA AND NAGAR HAVELI	35.538462

130 rows × 3 columns

In [466…

```
busiest_corridor_avg_dist = busy_corridor.groupby(["source_name", "destination_name"])["actual_distance_to_destination"].mean().sort_val
busiest_corridor_avg_dist = busiest_corridor_avg_dist.reset_index()
busiest_corridor_avg_dist.head()
```

Out[466…

	source_name	destination_name	actual_distance_to_destination
0	HARYANA	TAMIL NADU	1721.318473
1	PUNJAB	KARNATAKA	1703.183750
2	HARYANA	KARNATAKA	1689.694725
3	MAHARASHTRA	WEST BENGAL	1628.807438
4	ASSAM	MAHARASHTRA	1628.663803

In [467…

```
df_busiest_corridor_info = busiest_corridor_trip_count.merge(busiest_corridor_avg_time, on = ["source_name", "destination_name"])
df_busiest_corridor_info = df_busiest_corridor_info.merge(busiest_corridor_avg_dist, on = ["source_name", "destination_name"])
df_busiest_corridor_info = df_busiest_corridor_info.rename(columns = {"trip_uuid" : "trip_count", "actual_time" : "avg_time", "actual_di
df_busiest_corridor_info.head()
```

Out[467…

	index	source_name	destination_name	trip_count	avg_time	avg_distance
0	0	DELHI	HARYANA	378	142.150794	41.308429
1	1	HARYANA	DELHI	294	123.370748	44.194511
2	2	DELHI	UTTAR PRADESH	90	398.266667	130.901959
3	3	HARYANA	UTTAR PRADESH	88	317.988636	109.622126
4	4	HARYANA	PUNJAB	78	369.358974	167.022416

OBSERVATION : The busiest inter-city corridor is Delhi - Haryana with trip_count of 378, avg_time for trip of 142.15 and avg_distance of 41.3.

HYPOTHESIS TESTING:

1) Testing if the difference trip_duration and start_scan_to_end_scan is significant using **TWO SAMPLE T-TEST**

In [468…

```
df_tdsses = df_combined_times.copy()
df_tdsses["diff_trip_duration_scan"] = df_tdsses["trip_duration"] - df_tdsses["start_scan_to_end_scan"]
df_tdsses.head()
```

Out[468…

	trip_uuid	route_type	source_name	trip_start_date	destination_name	trip_end_date	trip_duration	actual_distance_to_destination	start_scan_to_end
0	trip-153671041653548748	FTL	MADHYA PRADESH	2018-09-12	HARYANA	2018-09-13	2260.109800	383.759164	1
1	trip-153671042288605164	Carting	KARNATAKA	2018-09-12	KARNATAKA	2018-09-12	181.611874	24.644021	
2	trip-153671043369099517	FTL	KARNATAKA	2018-09-12	PUNJAB	2018-09-14	3934.362520	237.439610	
3	trip-153671046011330457	Carting	MAHARASHTRA	2018-09-12	MAHARASHTRA	2018-09-12	100.494935	17.175274	
4	trip-153671052974046625	FTL	KARNATAKA	2018-09-12	KARNATAKA	2018-09-12	718.349042	41.317614	

In [469…

```
df_tdsses.describe()
```

Out[469…

	trip_duration	actual_distance_to_destination	start_scan_to_end_scan	actual_time	accumulated_actual_time	osrm_time	accumulated_osrm_time	osrm_dis
count	13886.000000	13886.000000	13886.000000	13886.000000	13886.000000	13886.000000	13886.000000	13886.00
mean	547.481429	112.203313	366.983869	357.224471	354.517068	161.361011	181.261270	204.42

	trip_duration	actual_distance_to_destination	start_scan_to_end_scan	actual_time	accumulated_actual_time	osrm_time	accumulated_osrm_time	osrm_dis
std	670.405221	249.958253	512.948026	563.367162	558.675986	272.139846	315.760533	371.5
min	23.461468	9.002461	20.000000	9.000000	9.000000	6.000000	6.000000	9.0
25%	151.212210	20.336659	112.000000	67.000000	66.000000	29.000000	30.000000	30.7
50%	288.308647	35.482491	193.000000	148.500000	147.000000	60.000000	65.000000	65.2
75%	672.193738	75.766009	387.000000	367.000000	364.000000	168.000000	184.000000	206.3
max	7898.551955	1927.447705	7898.000000	6265.000000	6230.000000	2032.000000	2564.000000	2840.0

Creating a function to remove outliers from data

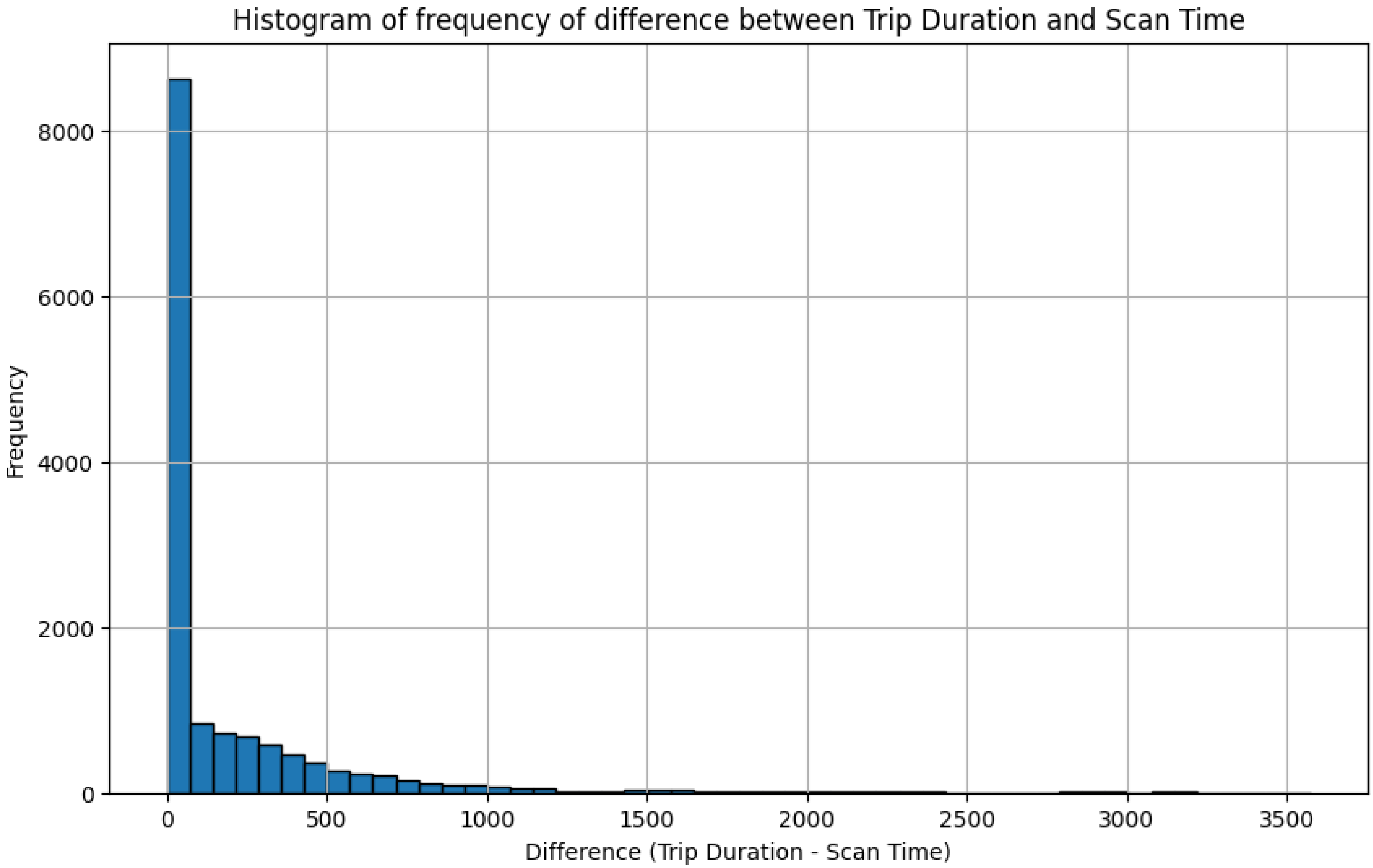
In [470...

```
def remove_outliers_iqr(df_in, column_in):
  q1 = df_in[column_in].quantile(0.25)
  q2 = df_in[column_in].quantile(0.75)
  iqr = q2 -q1
  lower_bound = q1 - 1.5 * iqr
  upper_bound = q2 + 1.5 * iqr
  df_out = df_in[(df_in[column_in] >= lower_bound) & (df_in[column_in] <= upper_bound)]

  return df_out
```

In [471...

```
import matplotlib.pyplot as plt
plt.figure(figsize=(10, 6))
plt.hist(df_tdsses["diff_trip_duration_scan"], bins=50, edgecolor='black')
plt.xlabel("Difference (Trip Duration - Scan Time)")
plt.ylabel("Frequency")
plt.title("Histogram of frequency of difference between Trip Duration and Scan Time")
plt.grid(True)
plt.show()
```



One trip has 3575 min difference between trip_duration and start_scan_to_end_scan. Delhivery needs to see in detail what happened during this trip to avoid similar time delay on other trips.

In [472…

```
most_delayed_trip = df_tdsses[df_tdsses["diff_trip_duration_scan"] == df_tdsses["diff_trip_duration_scan"].max()]
most_delayed_trip
```

Out[472…

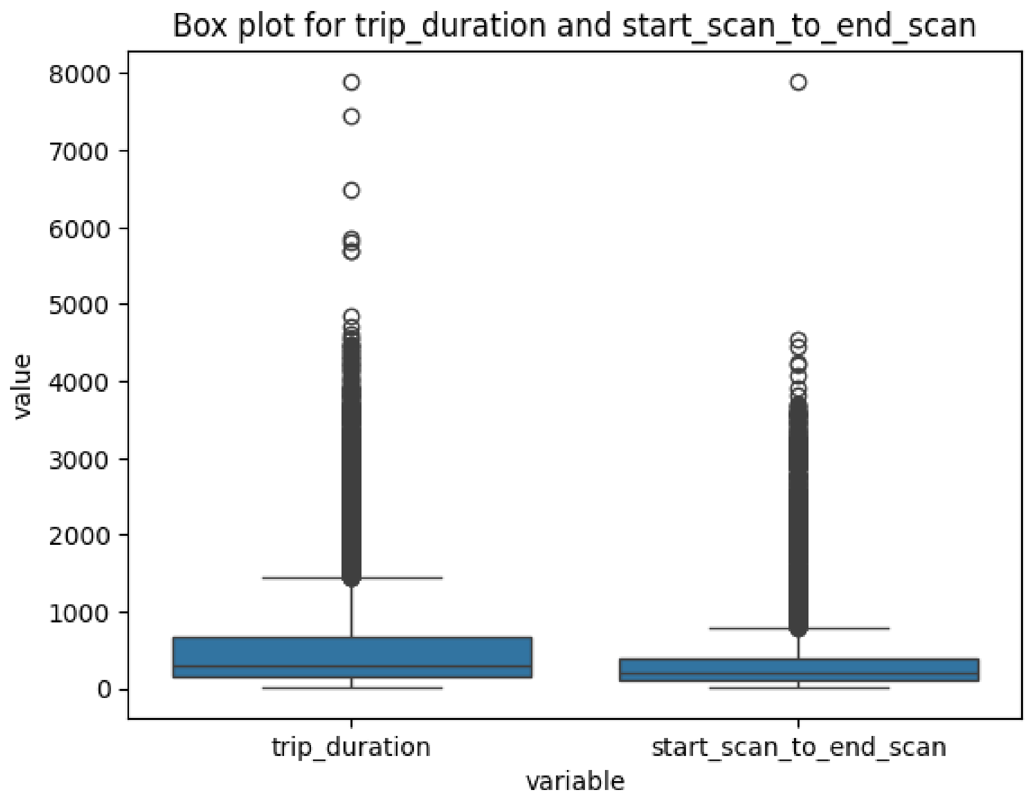
	trip_uuid	route_type	source_name	trip_start_date	destination_name	trip_end_date	trip_duration	actual_distance_to_destination	start_scan_to_er
7192	trip-153762877083011555	FTL	KARNATAKA	2018-09-22	PUNJAB	2018-09-25	4395.09742	236.729936	

In [473...

```
df_melted = pd.melt(df_tdsses.reset_index(), id_vars = ["index"], value_vars = ["trip_duration", "start_scan_to_end_scan"])

sns.boxplot(x = "variable", y = "value", data = df_melted)

plt.title("Box plot for trip_duration and start_scan_to_end_scan")
plt.show()
```



Removing outliers from the data for first hypothesis testing and plot

In [474...

```
data_without_outliers = remove_outliers_iqr(df_tdsses, 'diff_trip_duration_scan')
```

In [475...

```
data_without_outliers.describe()
```

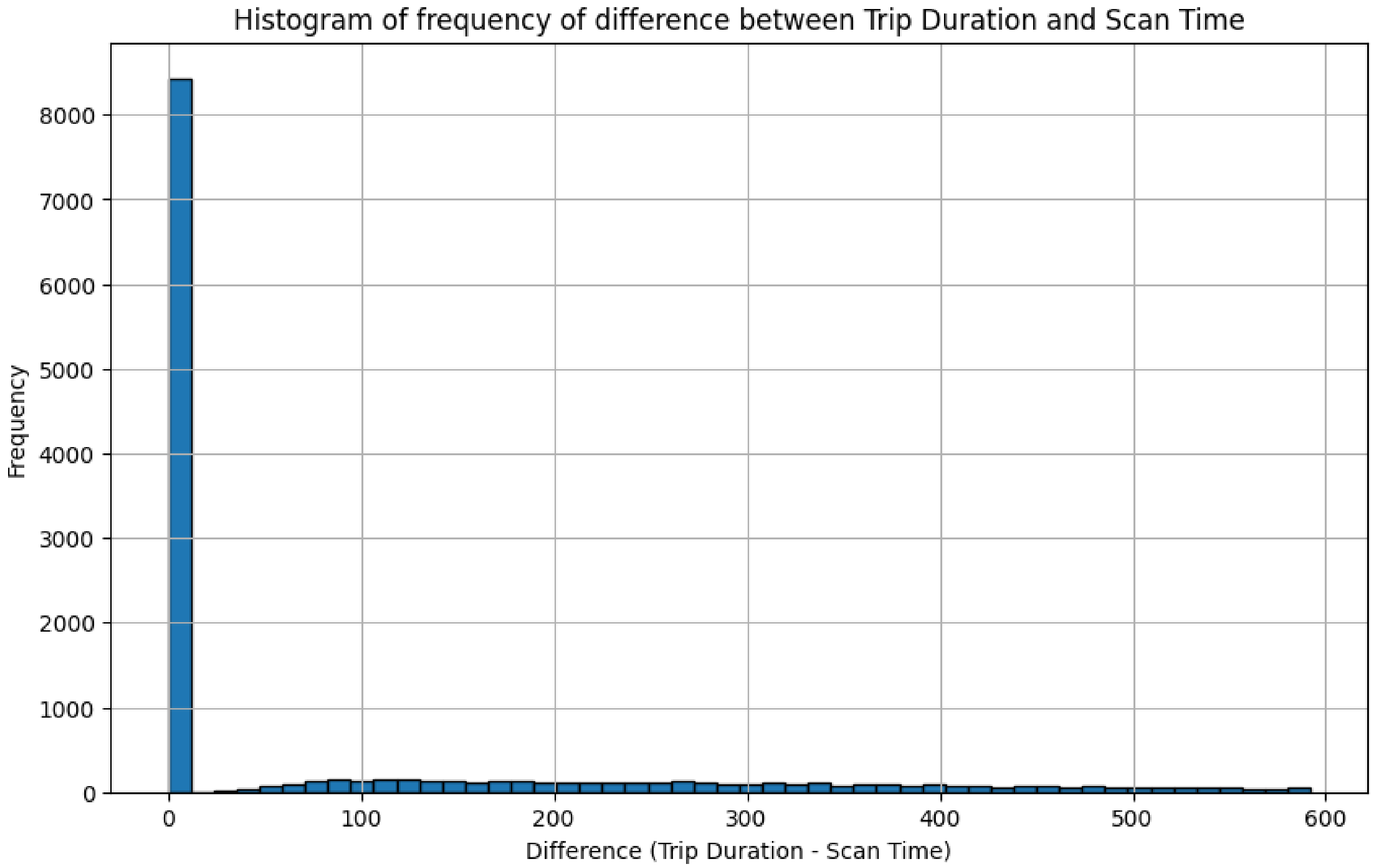
Out[475...

	trip_duration	actual_distance_to_destination	start_scan_to_end_scan	actual_time	accumulated_actual_time	osrm_time	accumulated_osrm_time	osrm_dis
count	12610.000000	12610.000000	12610.000000	12610.000000	12610.000000	12610.000000	12610.000000	12610.00
mean	434.753024	101.212537	345.697542	281.652498	279.243854	124.824187	139.981285	155.60
std	522.946584	241.232971	499.455847	453.692249	449.624460	217.165045	252.768832	296.47

	trip_duration	actual_distance_to_destination	start_scan_to_end_scan	actual_time	accumulated_actual_time	osrm_time	accumulated_osrm_time	osrm_dis
min	23.461468	9.002461	20.000000	9.000000	9.000000	6.000000	6.000000	9.07
25%	142.736354	19.409633	108.000000	63.000000	62.000000	28.000000	29.000000	29.04
50%	254.301224	32.211022	182.000000	126.000000	124.000000	53.000000	57.000000	52.85
75%	505.013967	64.024816	345.000000	292.000000	289.000000	129.000000	148.000000	155.11
max	7898.551955	1927.447705	7898.000000	4532.000000	4504.000000	1686.000000	1938.000000	2326.19

In [476…

```
plt.figure(figsize=(10, 6))
plt.hist(data_without_outliers["diff_trip_duration_scan"], bins=50, edgecolor='black')
plt.xlabel("Difference (Trip Duration - Scan Time)")
plt.ylabel("Frequency")
plt.title("Histogram of frequency of difference between Trip Duration and Scan Time")
plt.grid(True)
plt.show()
```



In [477…

```
from scipy import stats
t_statistic, p_value = stats.ttest_rel(data_without_outliers["trip_duration"], data_without_outliers["start_scan_to_end_scan"])
print("t-statistic:", t_statistic)
print("p-value:", p_value)

alpha = 0.05
if p_value < alpha:
    print("Reject the null hypothesis. There is a significant difference between the trip_duration and start_scan_to_end_scan.")
else:
    print("Fail to reject the null hypothesis. No significant difference between the trip_duration and start_scan_to_end_scan.")
```

```
t-statistic: 66.20000827034092
p-value: 0.0
Reject the null hypothesis. There is a significant difference between the trip_duration and start_scan_to_end_scan.
```

actual_time aggregated value and OSRM time aggregated value

In [478…

```
df_act_osrm_diff = df_combined_times["actual_time"] - df_combined_times["osrm_time"]
df_act_osrm_test = pd.concat([df_combined_times["actual_time"], df_combined_times["osrm_time"], df_act_osrm_diff], axis = 1)
df_act_osrm_test = df_act_osrm_test.rename(columns = {0 : "diff_actual_time_osrm_time"})
df_act_osrm_test
```

Out[478…

	actual_time	osrm_time	diff_actual_time_osrm_time
0	1562.0	717.0	845.0
1	143.0	68.0	75.0
2	3347.0	1740.0	1607.0
3	59.0	15.0	44.0
4	341.0	117.0	224.0
...	...	...	...
13881	83.0	62.0	21.0
13882	21.0	12.0	9.0
13883	282.0	48.0	234.0
13884	264.0	179.0	85.0
13885	275.0	68.0	207.0

13886 rows × 3 columns

In [479…

```
df_act_osrm_test.describe()
```

Out[479…

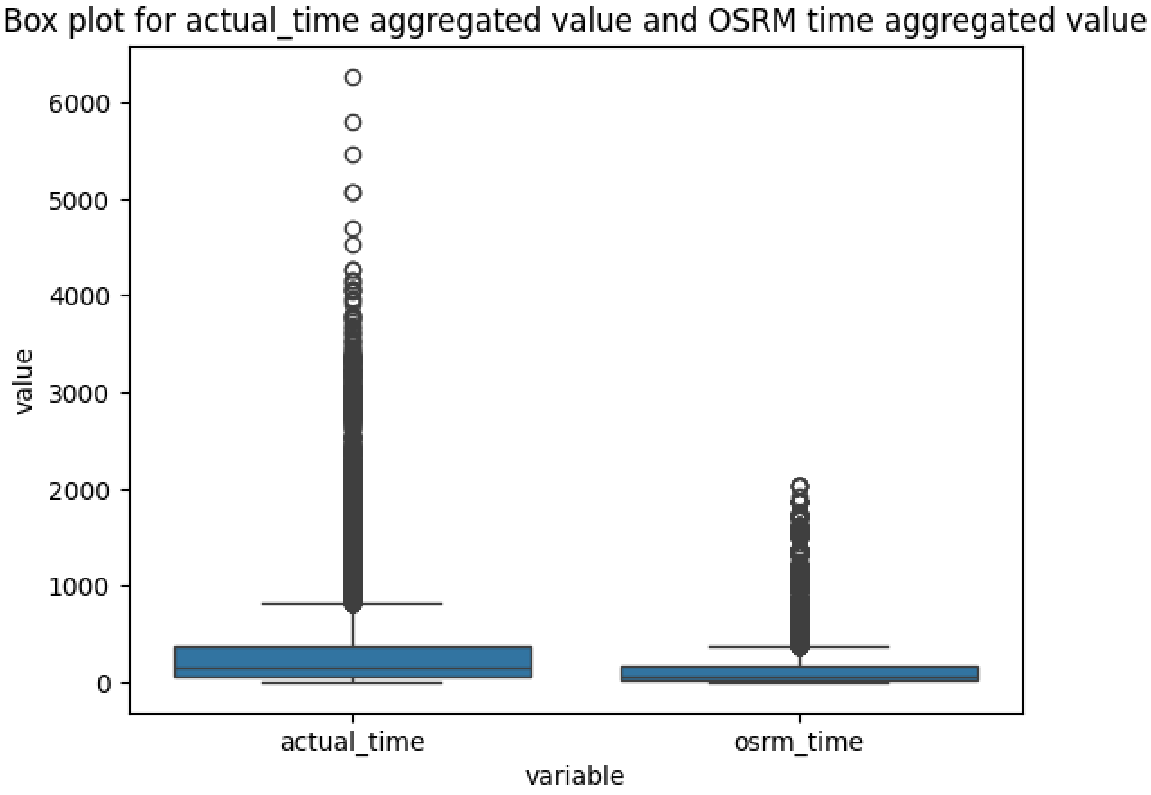
	actual_time	osrm_time	diff_actual_time_osrm_time
count	13886.000000	13886.000000	13886.000000
mean	357.224471	161.361011	195.863460
std	563.367162	272.139846	312.036942
min	9.000000	6.000000	-58.000000
25%	67.000000	29.000000	33.000000
50%	148.500000	60.000000	81.000000
75%	367.000000	168.000000	200.750000
max	6265.000000	2032.000000	4235.000000

In [480…

```
df_melted_1 = pd.melt(df_act_osrm_test.reset_index(), id_vars = ["index"], value_vars = ["actual_time", "osrm_time"])

sns.boxplot(x = "variable", y = "value", data = df_melted_1)

plt.title("Box plot for actual_time aggregated value and OSRM time aggregated value")
plt.show()
```



Removing outliers

In [481…

```
df_act_osrm_test_wo_outliers = remove_outliers_iqr(df_act_osrm_test, 'diff_actual_time_osrm_time')
```

In [482…

```
df_act_osrm_test_wo_outliers.describe()
```

Out[482…

	actual_time	osrm_time	diff_actual_time_osrm_time
count	12255.000000	12255.00000	12255.000000
mean	191.572664	90.04235	101.530314
std	181.943938	96.58130	98.634021

	actual_time	osrm_time	diff_actual_time_osrm_time
min	9.000000	6.00000	-58.000000
25%	62.000000	27.00000	29.000000
50%	120.000000	51.00000	65.000000
75%	266.500000	120.00000	144.000000
max	1160.000000	709.00000	452.000000

In [483...

```python
t_statistic, p_value = stats.ttest_rel(df_act_osrm_test_wo_outliers["actual_time"], df_act_osrm_test_wo_outliers["osrm_time"])
print("t-statistic:", t_statistic)
print("p-value:", p_value)

alpha = 0.05
if p_value < alpha:
    print("Reject the null hypothesis. There is a significant difference between the means of actual time and OSRM time.")
else:
    print("Fail to reject the null hypothesis. No significant difference between the means of actual time and OSRM time.")
```

```
t-statistic: 113.95297059478418
p-value: 0.0
Reject the null hypothesis. There is a significant difference between the means of actual time and OSRM time.
```

actual_time aggregated value and segment actual time aggregated value

In [484...

```python
df_atav = df.groupby(["trip_uuid", "destination_center"] )[["actual_time"]].last()
df_atav = df_atav.reset_index()
df_atav = df_atav.groupby("trip_uuid")["actual_time"].sum()
df_atav
```

Out[484...

	actual_time
trip_uuid	
trip-153671041653548748	1562.0
trip-153671042288605164	143.0
trip-153671043369099517	3347.0
trip-153671046011330457	59.0
trip-153671052974046625	341.0
...	...
trip-153861095625827784	83.0
trip-153861104386292051	21.0

	actual_time
trip_uuid	
trip-153861106442901555	282.0
trip-153861115439069069	264.0
trip-153861118270144424	275.0

13886 rows × 1 columns

dtype: float64

In [485…

```
df_atav_seg = df.groupby(["trip_uuid"])["segment_actual_time"].sum()
df_atav = df_atav.reset_index()
df_atav = df_atav.merge(df_atav_seg, left_on='trip_uuid', right_on='trip_uuid')
df_atav = df_atav.reset_index()
df_atav
```

Out[485…

	index	trip_uuid	actual_time	segment_actual_time
0	0	trip-153671041653548748	1562.0	1548.0
1	1	trip-153671042288605164	143.0	141.0
2	2	trip-153671043369099517	3347.0	3308.0
3	3	trip-153671046011330457	59.0	59.0
4	4	trip-153671052974046625	341.0	340.0
...	...	...	...	...
13881	13881	trip-153861095625827784	83.0	82.0
13882	13882	trip-153861104386292051	21.0	21.0
13883	13883	trip-153861106442901555	282.0	281.0
13884	13884	trip-153861115439069069	264.0	258.0
13885	13885	trip-153861118270144424	275.0	274.0

13886 rows × 4 columns

In [486…

```
df_atav["diff_actual_time_segment_actual_time"] = df_atav["actual_time"] - df_atav["segment_actual_time"]
df_atav
```

Out[486...

	index	trip_uuid	actual_time	segment_actual_time	diff_actual_time_segment_actual_time
0	0	trip-153671041653548748	1562.0	1548.0	14.0
1	1	trip-153671042288605164	143.0	141.0	2.0
2	2	trip-153671043369099517	3347.0	3308.0	39.0
3	3	trip-153671046011330457	59.0	59.0	0.0
4	4	trip-153671052974046625	341.0	340.0	1.0
...	...	...	...	...	...
13881	13881	trip-153861095625827784	83.0	82.0	1.0
13882	13882	trip-153861104386292051	21.0	21.0	0.0
13883	13883	trip-153861106442901555	282.0	281.0	1.0
13884	13884	trip-153861115439069069	264.0	258.0	6.0
13885	13885	trip-153861118270144424	275.0	274.0	1.0

13886 rows × 5 columns

In [487...

```
df_atav.describe()
```

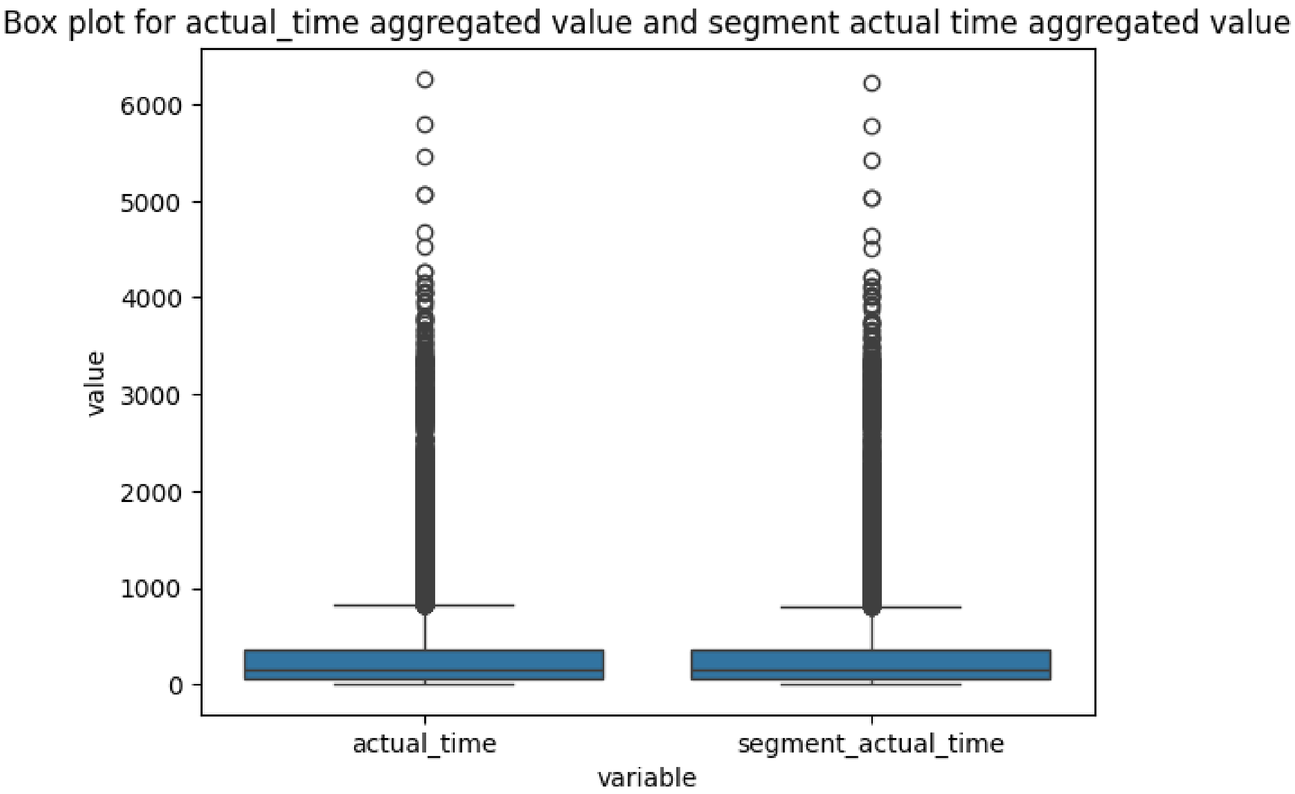
Out[487...

	index	actual_time	segment_actual_time	diff_actual_time_segment_actual_time
count	13886.000000	13886.000000	13886.000000	13886.000000
mean	6942.500000	357.224471	354.517068	2.707403
std	4008.687254	563.367162	558.675986	15.587310
min	0.000000	9.000000	9.000000	-692.000000
25%	3471.250000	67.000000	66.000000	1.000000
50%	6942.500000	148.500000	147.000000	1.000000
75%	10413.750000	367.000000	364.000000	3.000000
max	13885.000000	6265.000000	6230.000000	49.000000

In [488...

```
df_melted_2 = pd.melt(df_atav.reset_index(), id_vars = ["trip_uuid"], value_vars = ["actual_time", "segment_actual_time"])

sns.boxplot(x = "variable", y = "value", data = df_melted_2)
```



In [489…

```
df_atav_out = remove_outliers_iqr(df_atav, "diff_actual_time_segment_actual_time")
```

In [490…

```
df_atav_out.describe()
```

Out[490…

	index	actual_time	segment_actual_time	diff_actual_time_segment_actual_time
count	12226.000000	12226.000000	12226.000000	12226.000000
mean	6968.800671	206.758057	205.156306	1.601750
std	4024.241243	230.690712	229.885216	1.545385
min	1.000000	9.000000	9.000000	0.000000
25%	3491.250000	62.000000	61.000000	0.000000
50%	6984.500000	119.000000	118.000000	1.000000
75%	10474.750000	268.000000	265.000000	2.000000
max	13885.000000	3051.000000	3051.000000	6.000000

In [491…

```
t_statistic, p_value = stats.ttest_rel(df_atav_out["actual_time"], df_atav_out["segment_actual_time"])
print("t-statistic:", t_statistic)
print("p-value:", p_value)

alpha = 0.05
if p_value < alpha:
    print("Reject the null hypothesis. There is a significant difference between actual_time aggregated value and segment actual time ag
else:
    print("Fail to reject the null hypothesis. No significant difference between the actual_time aggregated value and segment actual tim
```

```
t-statistic: 114.60415429602853
p-value: 0.0
Reject the null hypothesis. There is a significant difference between actual_time aggregated value and segment actual time aggregated va
lue.
```

osrm distance aggregated value and segment osrm distance aggregated value

In [492…

```
df_odav = df.groupby(["trip_uuid", "destination_center"] )[["osrm_distance"]].last()
df_odav = df_odav.reset_index()
df_odav = df_odav.groupby("trip_uuid")["osrm_distance"].sum()
df_odav
```

Out[492…

	osrm_distance
trip_uuid	
trip-153671041653548748	991.3523
trip-153671042288605164	85.1110
trip-153671043369099517	2354.0665
trip-153671046011330457	19.6800
trip-153671052974046625	146.7918
...	...
trip-153861095625827784	73.4630
trip-153861104386292051	16.0882
trip-153861106442901555	58.9037
trip-153861115439069069	171.1103
trip-153861118270144424	80.5787

13886 rows × 1 columns

dtype: float64

In [493…

```
df_odav_seg = df.groupby(["trip_uuid"])["segment_osrm_distance"].sum()
df_odav = df_odav.reset_index()
df_odav = df_odav.merge(df_odav_seg, left_on='trip_uuid', right_on='trip_uuid')
df_odav = df_odav.reset_index()
df_odav["diff_osrm_distance_segment_osrm_distance"] = df_odav["segment_osrm_distance"] - df_odav["osrm_distance"]
df_odav
```

Out[493…

	index	trip_uuid	osrm_distance	segment_osrm_distance	diff_osrm_distance_segment_osrm_distance
0	0	trip-153671041653548748	991.3523	1320.4733	329.1210
1	1	trip-153671042288605164	85.1110	84.1894	-0.9216
2	2	trip-153671043369099517	2354.0665	2545.2678	191.2013
3	3	trip-153671046011330457	19.6800	19.8766	0.1966
4	4	trip-153671052974046625	146.7918	146.7919	0.0001
...	...	...	...	...	...
13881	13881	trip-153861095625827784	73.4630	64.8551	-8.6079
13882	13882	trip-153861104386292051	16.0882	16.0883	0.0001
13883	13883	trip-153861106442901555	58.9037	104.8866	45.9829
13884	13884	trip-153861115439069069	171.1103	223.5324	52.4221
13885	13885	trip-153861118270144424	80.5787	80.5787	0.0000

13886 rows × 5 columns

In [494…

```
df_odav.describe()
```

Out[494…

	index	osrm_distance	segment_osrm_distance	diff_osrm_distance_segment_osrm_distance
count	13886.000000	13886.000000	13886.000000	13886.000000
mean	6942.500000	204.427524	223.717759	19.290235
std	4008.687254	371.500357	418.230836	62.574964
min	0.000000	9.072900	9.072900	-63.777600
25%	3471.250000	30.715050	32.536550	0.000000
50%	6942.500000	65.279050	69.893950	1.070050

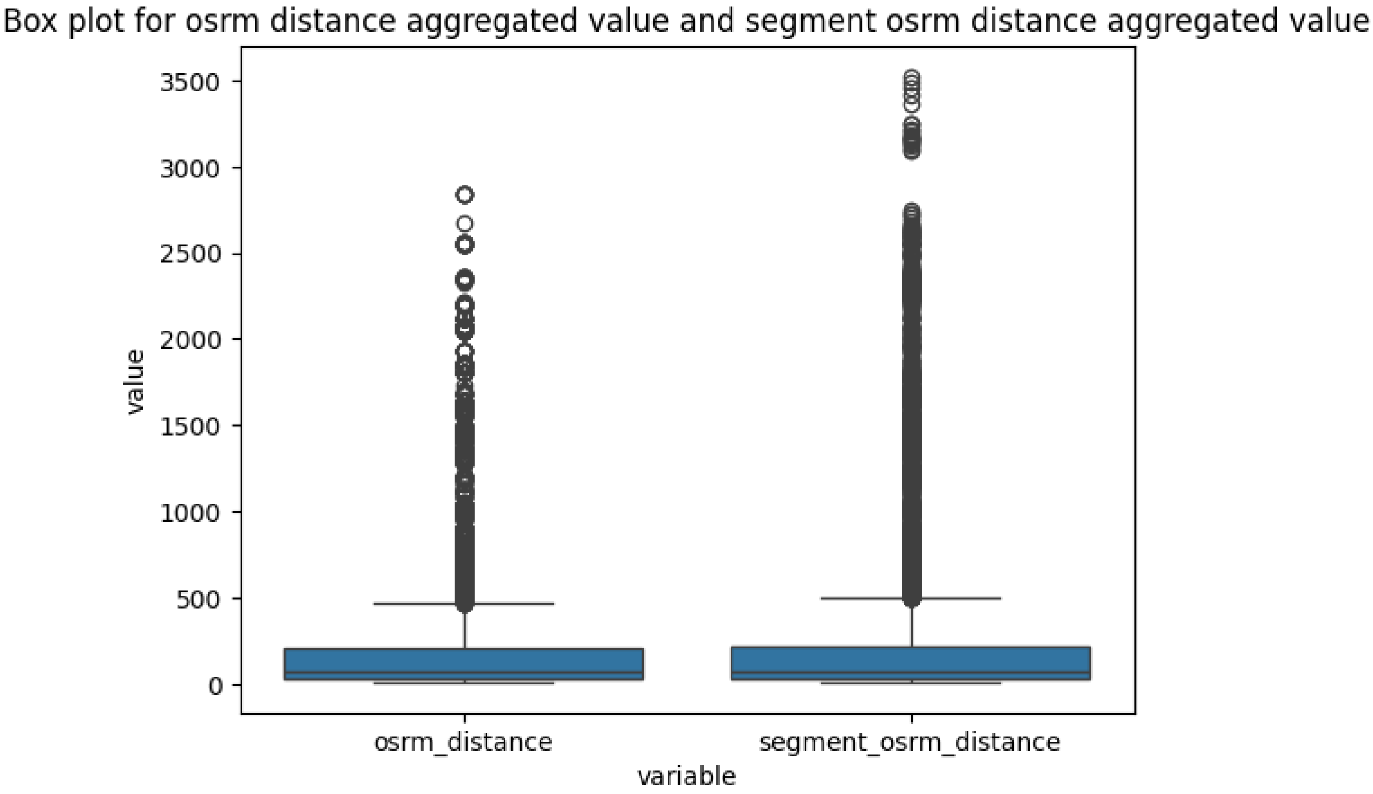
	index	osrm_distance	segment_osrm_distance	diff_osrm_distance_segment_osrm_distance
75%	10413.750000	206.312975	217.413800	11.066075
max	13885.000000	2840.081000	3523.632400	814.338100

In [495…

```
df_melted_3 = pd.melt(df_odav.reset_index(), id_vars = ["trip_uuid"], value_vars = ["osrm_distance", "segment_osrm_distance"])

sns.boxplot(x = "variable", y = "value", data = df_melted_3)

plt.title("Box plot for osrm distance aggregated value and segment osrm distance aggregated value")
plt.show()
```



In [496…

```
df_odav_out = remove_outliers_iqr(df_odav, "diff_osrm_distance_segment_osrm_distance")
```

In [497…

```
df_odav_out.describe()
```

Out[497…

	index	osrm_distance	segment_osrm_distance	diff_osrm_distance_segment_osrm_distance
count	11642.000000	11642.000000	11642.000000	11642.000000
mean	6960.771345	106.179303	109.061455	2.882152
std	4016.936646	143.249945	144.799905	6.958126
min	1.000000	9.072900	9.072900	-16.560000
25%	3491.250000	27.902875	29.045550	0.000000
50%	6961.500000	46.804600	52.472000	0.003700
75%	10444.750000	135.382300	138.896125	4.597875
max	13885.000000	2191.403700	2191.403700	27.638800

In [498…

```python
t_statistic, p_value = stats.ttest_rel(df_odav["osrm_distance"], df_odav["segment_osrm_distance"])
print("t-statistic:", t_statistic)
print("p-value:", p_value)

alpha = 0.05
if p_value < alpha:
    print("Reject the null hypothesis. There is a significant difference between the means of osrm_distance and segment_osrm_distance.")
else:
    print("Fail to reject the null hypothesis. No significant difference between the means of osrm_distance and segment_osrm_distance.")
```

```
t-statistic: -36.326662531995815
p-value: 4.16124894311804e-276
Reject the null hypothesis. There is a significant difference between the means of osrm_distance and segment_osrm_distance.
```

hypothesis testing/ visual analysis between osrm time aggregated value and segment osrm time aggregated value

In [499…

```python
df_otav = df.groupby(["trip_uuid", "destination_center"] )[["osrm_time"]].last()
df_otav = df_otav.reset_index()
df_otav = df_otav.groupby("trip_uuid")["osrm_time"].sum()
```

In [500…

```python
df_otav_seg = df.groupby(["trip_uuid"])["segment_osrm_time"].sum()
df_otav = df_otav.reset_index()
df_otav = df_otav.merge(df_otav_seg, left_on='trip_uuid', right_on='trip_uuid')
df_otav = df_otav.reset_index()
df_otav["diff_osrm_time_segment_osrm_time"] = df_otav["segment_osrm_time"] - df_otav["osrm_time"]
df_otav
```

Out[500…

	index	trip_uuid	osrm_time	segment_osrm_time	diff_osrm_time_segment_osrm_time
0	0	trip-153671041653548748	717.0	1008.0	291.0

	index	trip_uuid	osrm_time	segment_osrm_time	diff_osrm_time_segment_osrm_time
1	1	trip-153671042288605164	68.0	65.0	-3.0
2	2	trip-153671043369099517	1740.0	1941.0	201.0
3	3	trip-153671046011330457	15.0	16.0	1.0
4	4	trip-153671052974046625	117.0	115.0	-2.0
...	...	...	...	...	...
13881	13881	trip-153861095625827784	62.0	62.0	0.0
13882	13882	trip-153861104386292051	12.0	11.0	-1.0
13883	13883	trip-153861106442901555	48.0	88.0	40.0
13884	13884	trip-153861115439069069	179.0	221.0	42.0
13885	13885	trip-153861118270144424	68.0	67.0	-1.0

13886 rows × 5 columns

In [501…

```
df_otav.describe()
```

Out[501…

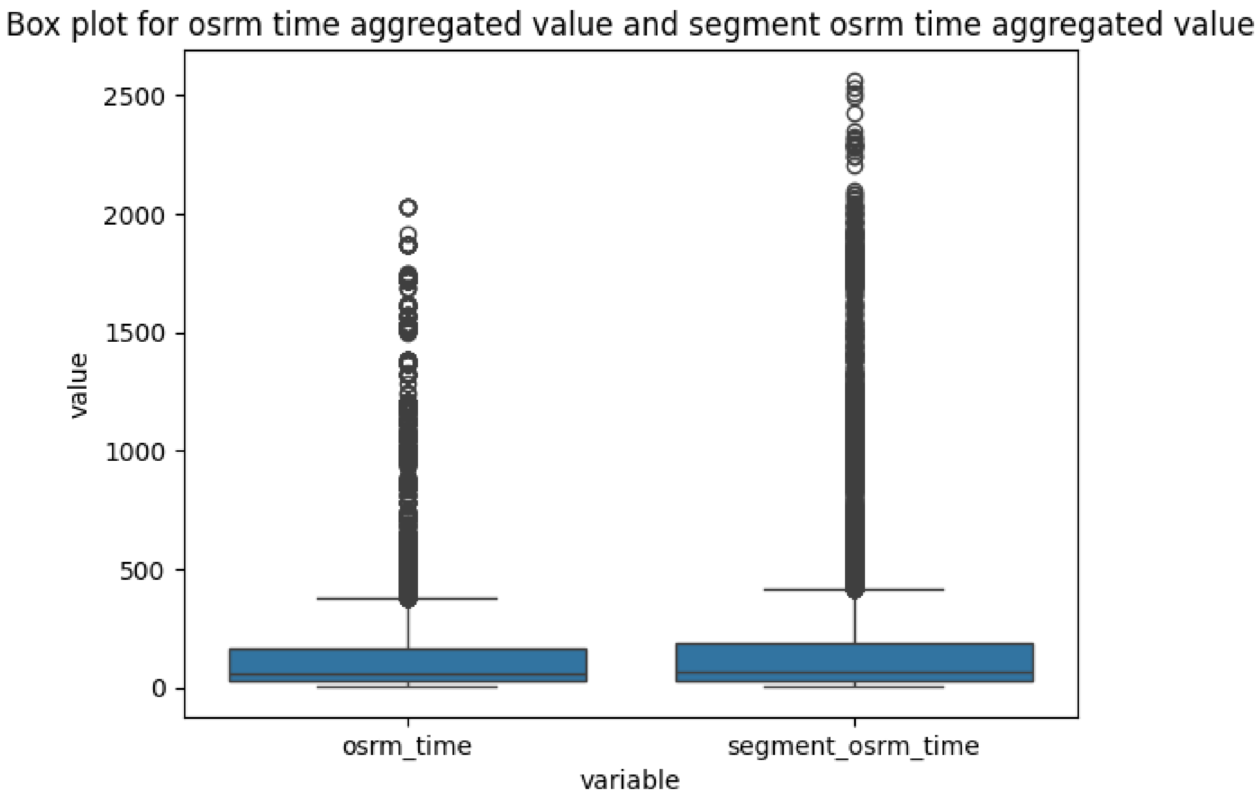
	index	osrm_time	segment_osrm_time	diff_osrm_time_segment_osrm_time
count	13886.000000	13886.000000	13886.000000	13886.000000
mean	6942.500000	161.361011	181.261270	19.900259
std	4008.687254	272.139846	315.760533	55.656760
min	0.000000	6.000000	6.000000	-22.000000
25%	3471.250000	29.000000	30.000000	-1.000000
50%	6942.500000	60.000000	65.000000	1.000000
75%	10413.750000	168.000000	184.000000	14.000000
max	13885.000000	2032.000000	2564.000000	691.000000

In [502…

```
df_melted_5 = pd.melt(df_otav.reset_index(), id_vars = ["trip_uuid"], value_vars = ["osrm_time", "segment_osrm_time"])

sns.boxplot(x = "variable", y = "value", data = df_melted_5)

plt.title("Box plot for osrm time aggregated value and segment osrm time aggregated value")
plt.show()
```



In [503…

```
df_otav_out = remove_outliers_iqr(df_otav, "diff_osrm_time_segment_osrm_time")
```

In [504…

```
df_otav_out.describe()
```

Out[504…

	index	osrm_time	segment_osrm_time	diff_osrm_time_segment_osrm_time
count	12007.000000	12007.000000	12007.000000	12007.000000
mean	6946.192055	93.731906	97.760140	4.028234
std	4014.461562	119.210060	121.901811	8.497559
min	1.000000	6.000000	6.000000	-22.000000
25%	3483.000000	27.000000	28.000000	-1.000000
50%	6939.000000	50.000000	53.000000	0.000000
75%	10428.500000	120.000000	127.000000	6.000000
max	13885.000000	1611.000000	1611.000000	36.000000

In [505…

```python
t_statistic, p_value = stats.ttest_rel(df_otav_out["osrm_time"], df_otav_out["segment_osrm_time"])
print("t-statistic:", t_statistic)
print("p-value:", p_value)

alpha = 0.05
if p_value < alpha:
    print("Reject the null hypothesis. There is a significant difference between osrm time aggregated value and segment osrm time aggreg
else:
    print("Fail to reject the null hypothesis. No significant difference between osrm time aggregated value and segment osrm time aggreg
```

```
t-statistic: -51.94427501526367
p-value: 0.0
Reject the null hypothesis. There is a significant difference between osrm time aggregated value and segment osrm time aggregated value.
```

Hot encoding of categorical variables

In [506…

```python
df_route_type = df.groupby("trip_uuid")["route_type"].first()
df_route_type.reset_index()
df_route_type
```

Out[506…

	route_type
trip_uuid	
trip-153671041653548748	FTL
trip-153671042288605164	Carting
trip-153671043369099517	FTL
trip-153671046011330457	Carting
trip-153671052974046625	FTL
...	...
trip-153861095625827784	Carting
trip-153861104386292051	Carting
trip-153861106442901555	Carting
trip-153861115439069069	Carting
trip-153861118270144424	FTL

13886 rows × 1 columns

dtype: object

In [507…

```
df_route_type.value_counts()
```

Out[507…

	count
route_type	
Carting	8363
FTL	5523

dtype: int64

In [508…

```
df_combined_times['route_type'] = df_combined_times['route_type'].map({'FTL':0, 'Carting':1})
df_combined_times.head()
```

Out[508…

	trip_uuid	route_type	source_name	trip_start_date	destination_name	trip_end_date	trip_duration	actual_distance_to_destination	start_scan_to_end
0	trip-153671041653548748	0	MADHYA PRADESH	2018-09-12	HARYANA	2018-09-13	2260.109800	383.759164	1
1	trip-153671042288605164	1	KARNATAKA	2018-09-12	KARNATAKA	2018-09-12	181.611874	24.644021	
2	trip-153671043369099517	0	KARNATAKA	2018-09-12	PUNJAB	2018-09-14	3934.362520	237.439610	
3	trip-153671046011330457	1	MAHARASHTRA	2018-09-12	MAHARASHTRA	2018-09-12	100.494935	17.175274	
4	trip-153671052974046625	0	KARNATAKA	2018-09-12	KARNATAKA	2018-09-12	718.349042	41.317614	

Normalize/ Standardize the numerical features using MinMaxScaler or StandardScaler

In [509…

```
df_scaled = df_combined_times.copy()
df_scaled = df_scaled.drop(columns = ["trip_uuid", "trip_start_date", "trip_end_date", "source_name", "destination_name"])
df_scaled
```

Out[509…

	route_type	trip_duration	actual_distance_to_destination	start_scan_to_end_scan	actual_time	accumulated_actual_time	osrm_time	accumulated_osrm_time
0	0	2260.109800	383.759164	1260.0	1562.0	1548.0	717.0	1008.0
1	1	181.611874	24.644021	58.0	143.0	141.0	68.0	65.0
2	0	3934.362520	237.439610	834.0	3347.0	3308.0	1740.0	1941.0
3	1	100.494935	17.175274	100.0	59.0	59.0	15.0	16.0

	route_type	trip_duration	actual_distance_to_destination	start_scan_to_end_scan	actual_time	accumulated_actual_time	osrm_time	accumulated_osrm_time
4	0	718.349042	41.317614	485.0	341.0	340.0	117.0	115.0
...	...	...	...	...	...	...	...	...
13881	1	405.485842	31.261599	105.0	83.0	82.0	62.0	62.0
13882	1	60.590521	15.513784	60.0	21.0	21.0	12.0	11.0
13883	1	422.119867	19.349008	248.0	282.0	281.0	48.0	88.0
13884	1	348.512862	33.673835	91.0	264.0	258.0	179.0	221.0
13885	0	354.407571	40.546740	287.0	275.0	274.0	68.0	67.0

13886 rows × 10 columns

In [510…

```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
scaled_data = scaler.fit_transform(df_scaled)
df_scaled_data = pd.DataFrame(scaled_data, columns = df_scaled.columns)
df_scaled_data.head()
```

Out[510…

	route_type	trip_duration	actual_distance_to_destination	start_scan_to_end_scan	actual_time	accumulated_actual_time	osrm_time	accumulated_osrm_time	osrm
0	-1.230534	2.554709	1.086444	1.741011	2.138603	2.136347	2.041814	2.618340	
1	0.812655	-0.545764	-0.350308	-0.602390	-0.380271	-0.382198	-0.343075	-0.368208	
2	-1.230534	5.052173	0.501047	0.910488	5.307166	5.286766	5.801046	5.573217	
3	0.812655	-0.666765	-0.380189	-0.520508	-0.529380	-0.528979	-0.537835	-0.523394	
4	-1.230534	0.254881	-0.283600	0.230083	-0.028800	-0.025986	-0.163014	-0.209854	

In [511…

```
df_scaled_data.describe()
```

Out[511…

	route_type	trip_duration	actual_distance_to_destination	start_scan_to_end_scan	actual_time	accumulated_actual_time	osrm_time	accumulated_osrn
count	1.388600e+04	1.388600e+04	1.388600e+04	1.388600e+04	1.388600e+04	1.388600e+04	1.388600e+04	1.38860
mean	-4.707614e-17	-3.326032e-17	-2.558486e-17	4.042408e-17	-2.200298e-17	3.019013e-17	-2.046789e-17	-2.14912
std	1.000036e+00	1.000036e+00	1.000036e+00	1.000036e+00	1.000036e+00	1.000036e+00	1.000036e+00	1.00003
min	-1.230534e+00	-7.816747e-	-4.128872e-01	-6.764747e-01	-6.181351e-	-6.184793e-01	-5.709072e-	-5.55064

	route_type	trip_duration	actual_distance_to_destination	start_scan_to_end_scan	actual_time	accumulated_actual_time	osrm_time	accumulated_osrm
		01			01		01	
25%	-1.230534e+00	-5.911104e-01	-3.675412e-01	-4.971128e-01	-5.151790e-01	-5.164486e-01	-4.863888e-01	-4.7905
50%	8.126555e-01	-3.866052e-01	-3.069456e-01	-3.391964e-01	-3.705079e-01	-3.714578e-01	-3.724727e-01	-3.6820
75%	8.126555e-01	1.860320e-01	-1.457788e-01	3.902316e-02	1.735259e-02	1.697455e-02	2.439638e-02	8.6737
max	8.126555e-01	1.096551e+01	7.262452e+00	1.468236e+01	1.048692e+01	1.051718e+01	6.874063e+00	7.5463

INSIGHTS:

1. The data is of 23 Days starting from 2018-09-12 and ending on 2018-10-04.
2. The data has 136557 entries across 24 columns. But the analysis is performed on 136059 after removing some incomplete rows/data.
3. No packages were returned to source location. That means all the packages were transported and delivered as destination.
4. **13886 trips were made during these 23 days.**
5. Most busy day was 2018-09-15, on which 775 trips were made.
6. **Maharashtra is the busiest state in terms of trips which are made from and to state, followed by Karnataka and Haryana.**
7. Nagaland is the least busiest state handling 5 trips as source_center and 1 trips as destination_center. It is followed by Mizoram.
8. **The busiest inter-city corridor is Delhi - Haryana with trip_count of 378, avg_time for trip of 142.15 and avg_distance of 41.3**
9. Based on Hypothesis tests done between:

    - trip_duration and start_scan_to_end_scan
    - actual_time aggregated value and OSRM time aggregated value
    - actual_time aggregated value and segment actual time aggregated value
    - osrm distance aggregated value and segment osrm distance aggregated value
    - osrm time aggregated value and segment osrm time aggregated value

    It is observed that there is significant difference betweeen actual values and OSRM values.

10. Frequency of Carting is 8363 and FTL 5523 for the trips.

RECOMMENDATIONS:

1. Looking at the data, it can be seen that the number of trips were mostly in the range of 500 to 600. It can be incresed to 700 - 800 range with better planning and management for better business and profits.

2. **Maharashtra, Karnataka, and Haryana are strong states for business since they have the most trips IN and OUT. We need to focus on these states to make a robust model which we can replicate in other target states and futher move on to international trips.**
3. Eastern states have very few trips. It may be mostly due to limitations in mode of transportation or difficulty in movement. We need to study local geography of these states and innovate to create more trips in these States to increase foothold and provide our service before competetion.
4. Inter-state trip is comparatively less that inter-city trips as seen from number of inter-city trips (Maharashta at more than 2000 trips) and number of inter-state trips (DELHI - HARYANA - 378 trips). We should tap the business opportunity of inter-state trip and move on to international trips.
5. The algorithm used for calculating the OSRM parameters should be optimized to have it more closer to actual parameters. This will lead us to better management of trips setting better customer satisfaction.