MIT Center for Transportation & Logistics

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Optimal Green Fleet Composition through Machine Learning

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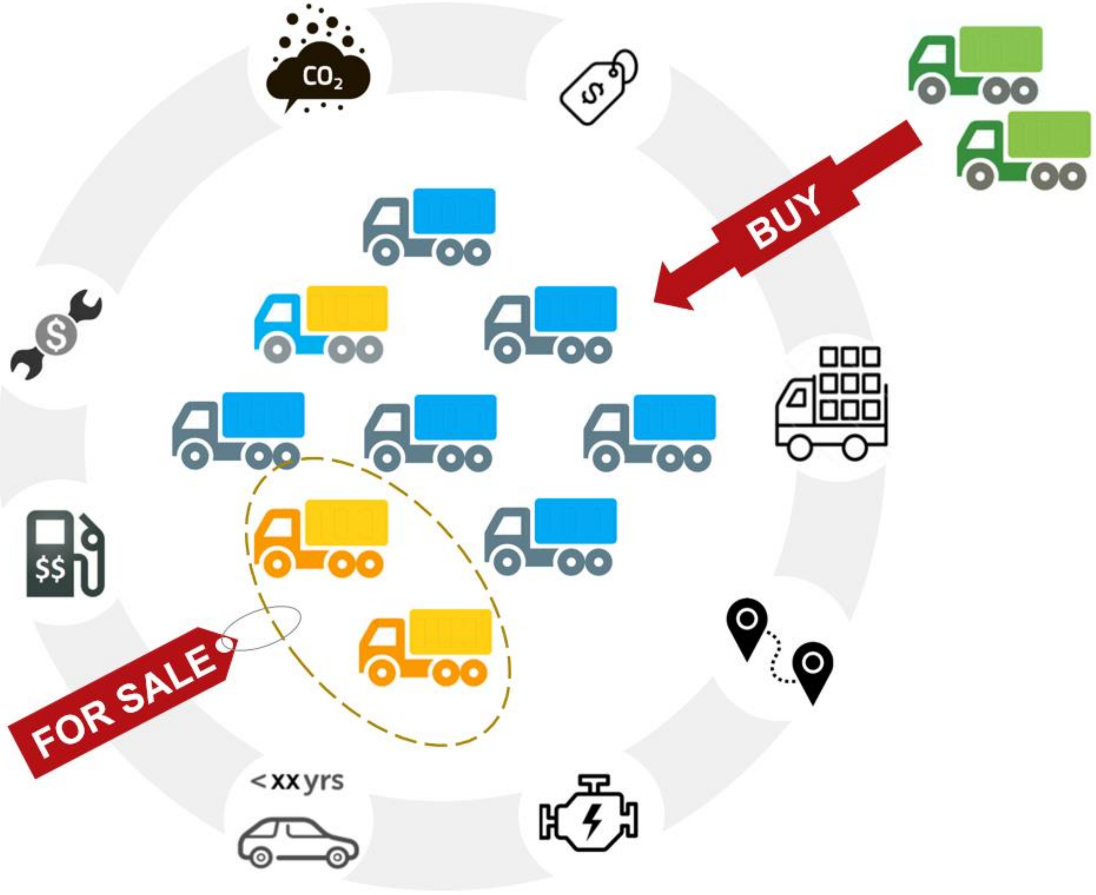
http://**sustainablelogistics**.mit.edu

Agenda

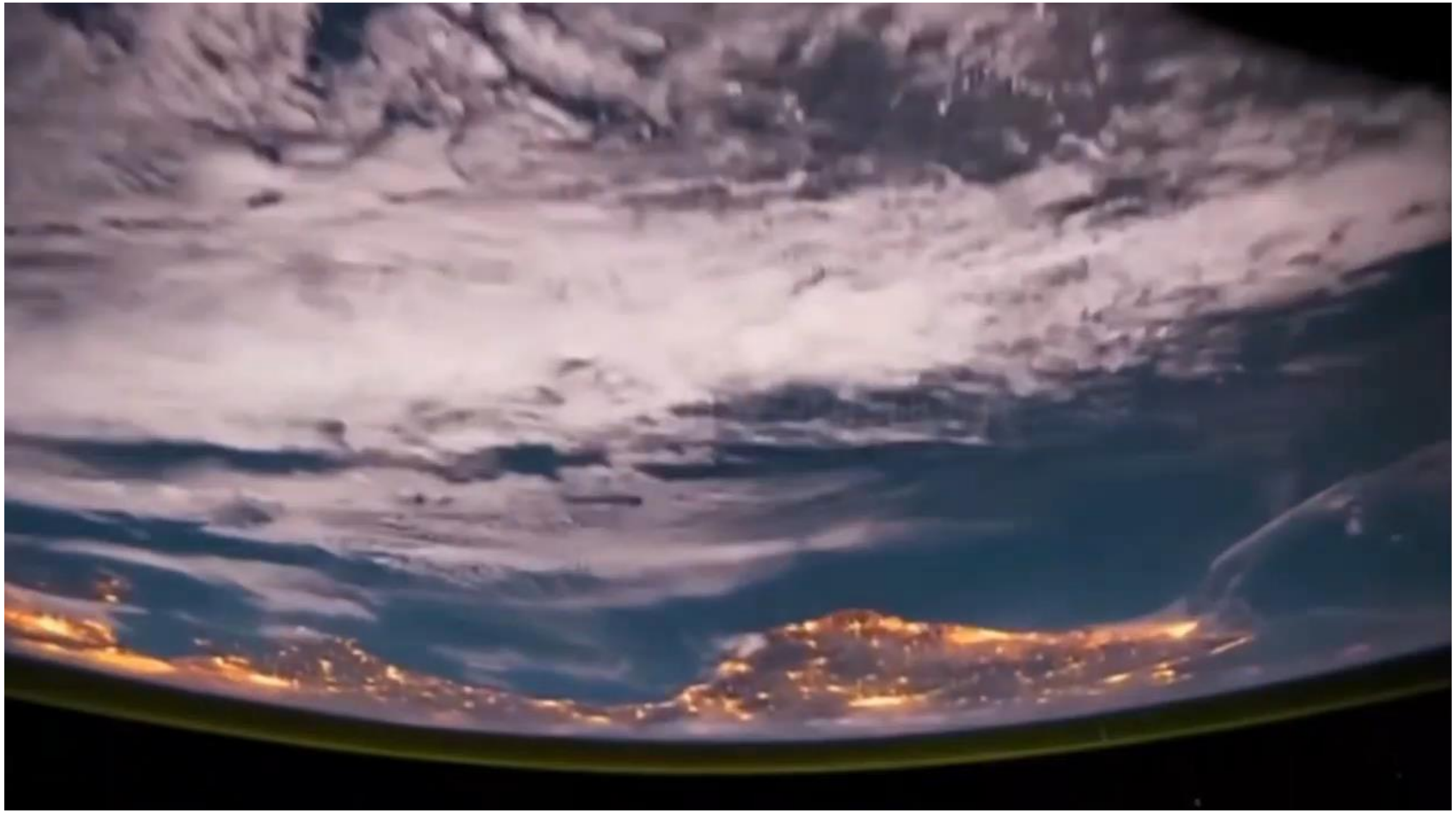
1. What is our project all about?
2. Why this is relevant?
3. What others have done?
4. What is our approach?
5. Results
6. Managerial Implications

What is our project all about?

Formulating a fleet composition strategy not just based on costs and service but also based on ***CO_2 emissions***



Why this is relevant?



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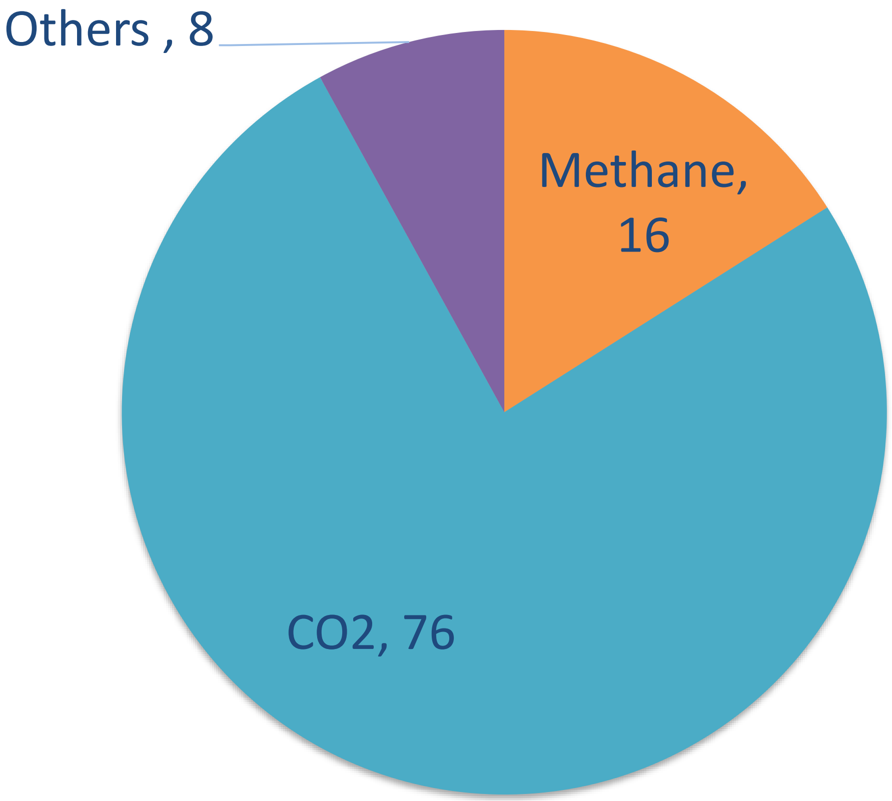
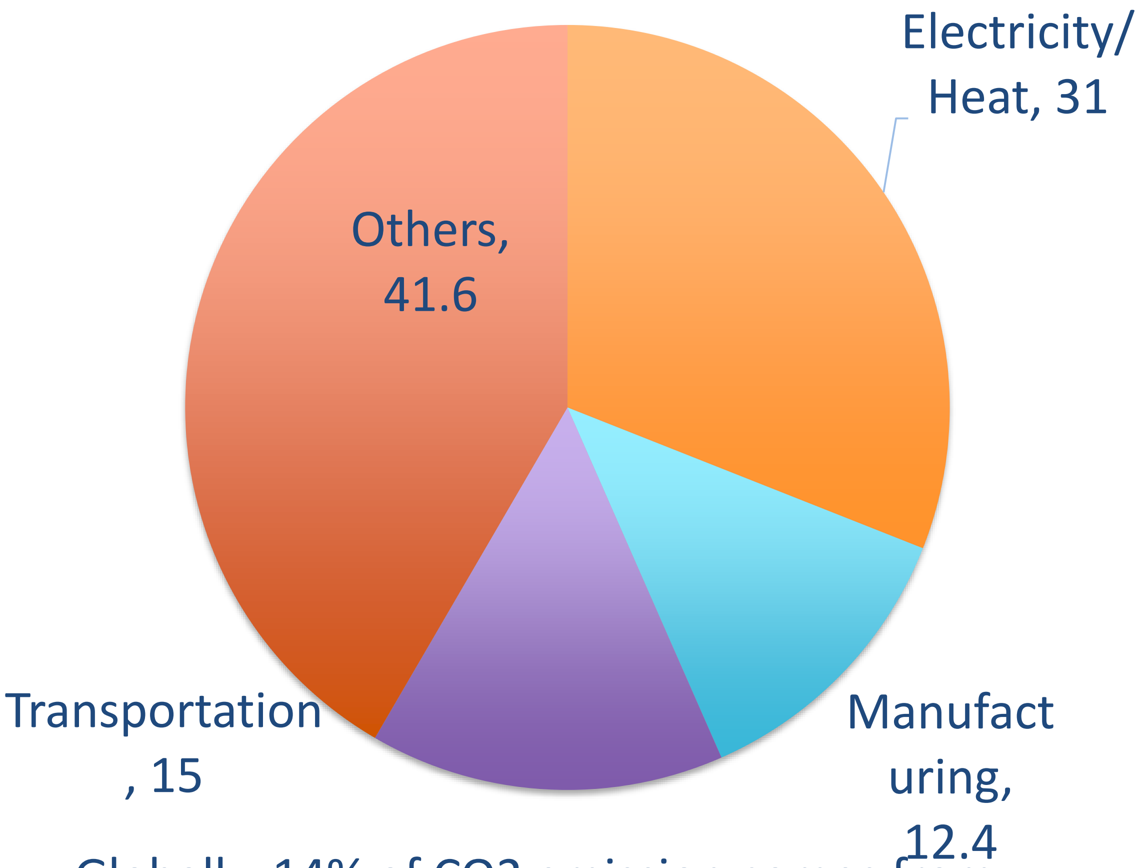


CO_2 makes 76% of Green House Gas Emissions



Globally, 14% of CO2 emission comes from transport sector and this may double by 2050

Our Sponsor Company

- **One of the largest retailers in Mexico**
- Furniture, Appliances, Apparel
- ~6 Billion USD of Revenue

- 1300 Stores
- 19 Regional DCs
- **1200 Last Mile Vehicles**
- **590 Inbound Vehicles**

What others have done?

Individual Vehicle Base

- Ahmed, 1973
- Chisholm, 1974
- Evans, 1989

Overall fleet Approach

- Redmer, 2016
- Ahani, Arantes, & Melo, 2016

Green Fleet Approach

- Gong & Wu, 2011
- Stasko & Gao, 2012

Our approach

Formulate an optimization model that proposes vehicle replacement timeline

Identify vehicle characteristics that have the biggest impact on CO_2 emissions using Machine Learning

Coppel Inbound Fleet Composition Decision

Our approach-Part 1: Create optimization model

Optimization model will make retirement decisions for each vehicle over a period of 5 years.

- Running Costs (Fuel, Maintenance etc)
- Purchase Price
- Resale Price

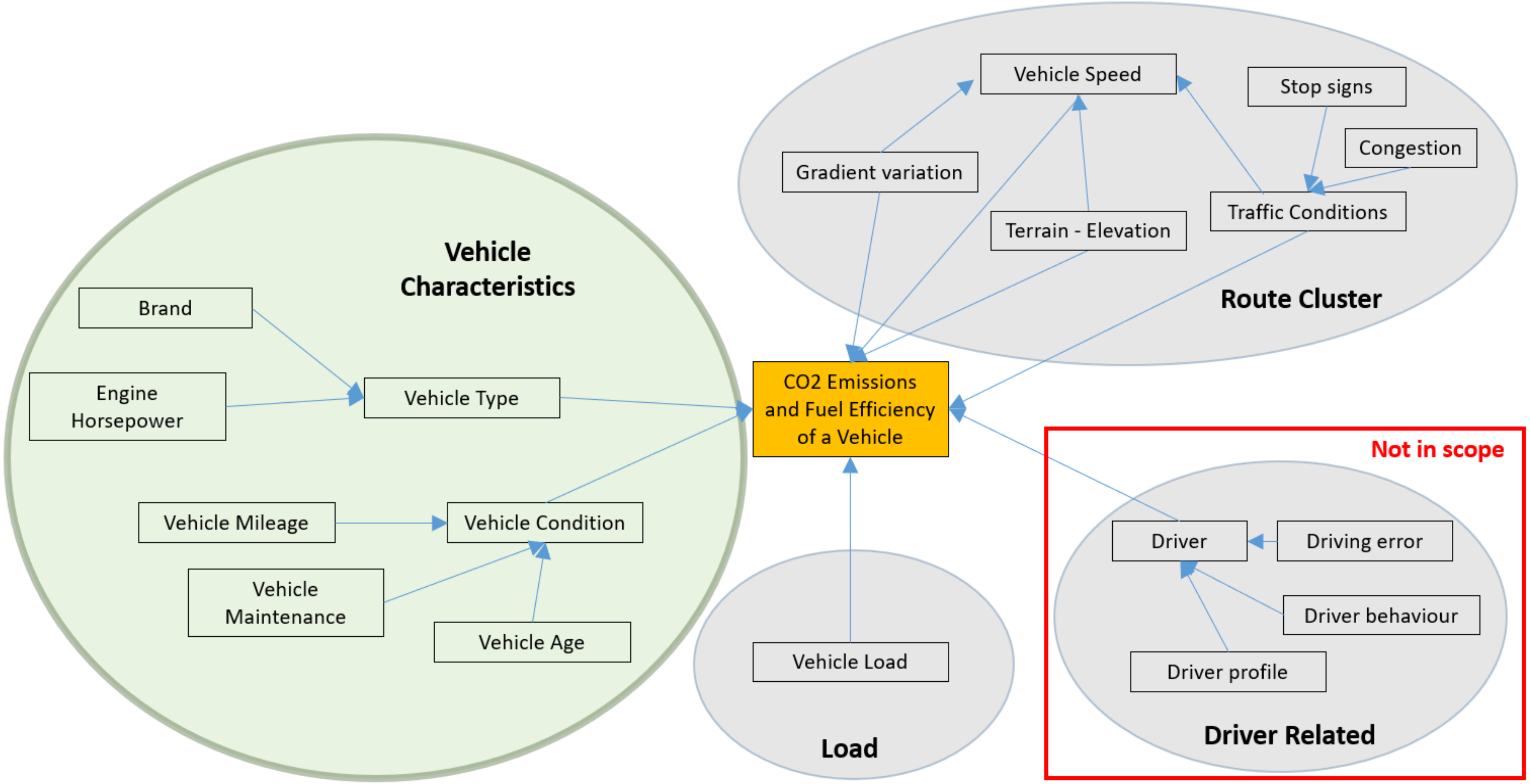
Minimize Total Cost

- Retirement Decision per Vehicle per Year (Sell or Keep)

- Fleet Demand (Min-Max vehicles that can be replaced every year)
- Fleet CO2 Emissions Budget

Our approach-Part 2: Identify vehicle characteristics

Isolate vehicle characteristics by analyzing vehicles in same route cluster and load bin.



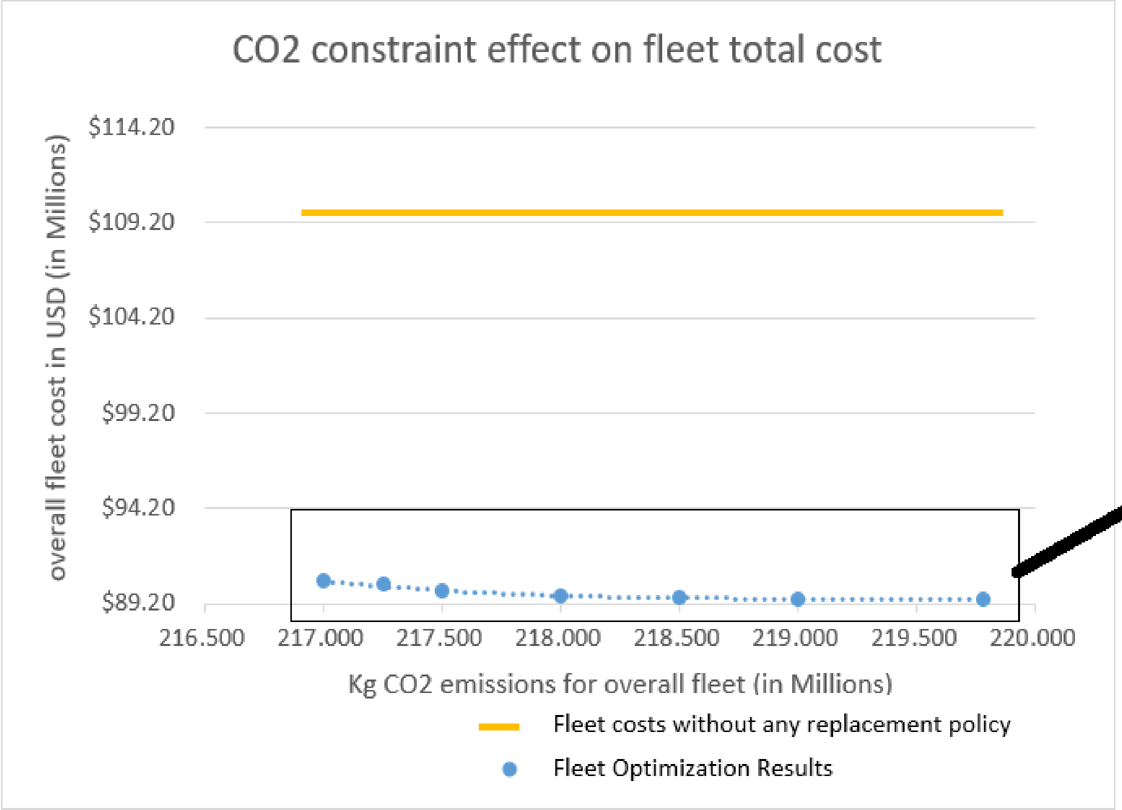
Results-Part 1: Create Optimization Model

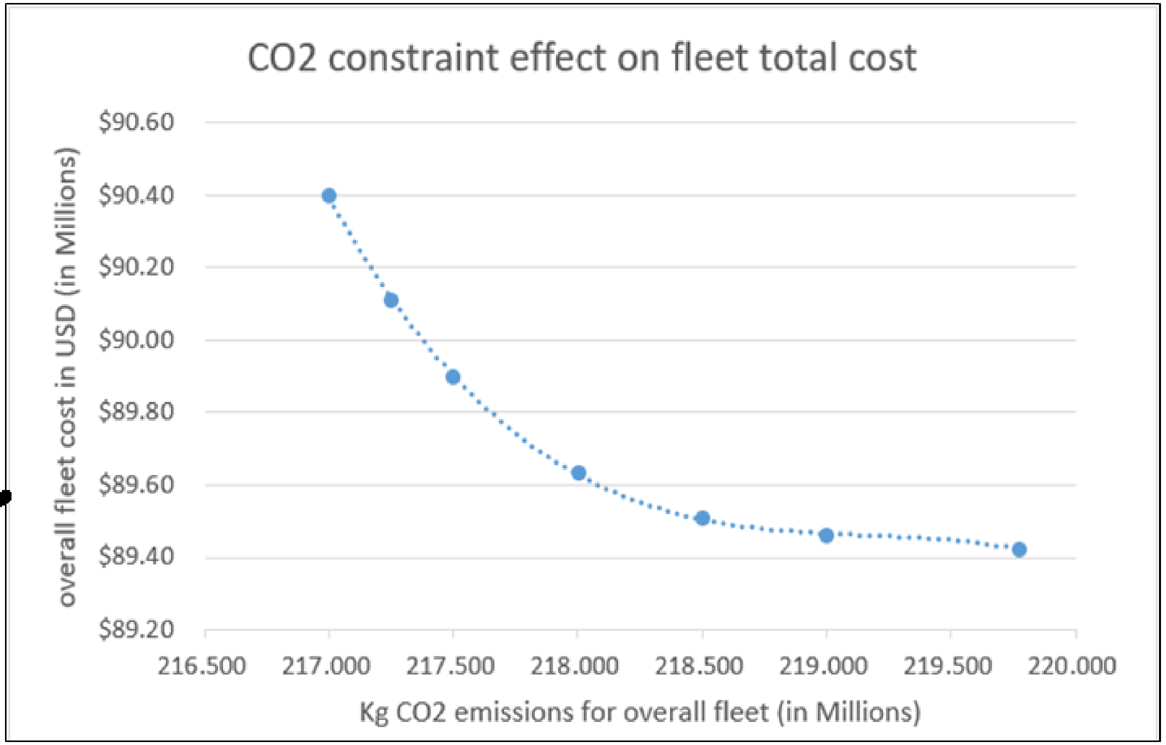
We run the optimization model with a relaxed CO_2 constraint, the model proposed to sell 213 vehicles from fleet of 402 vehicles.

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Vehicle 386	SELL	KEEP	KEEP	KEEP	KEEP
Vehicle 387	KEEP	SELL	KEEP	KEEP	KEEP
Vehicle 388	SELL	KEEP	KEEP	KEEP	KEEP
Vehicle 389	KEEP	SELL	KEEP	KEEP	KEEP
Vehicle 390	SELL	KEEP	KEEP	KEEP	KEEP
Vehicle 391	SELL	KEEP	KEEP	KEEP	KEEP
Vehicle 392	SELL	KEEP	KEEP	KEEP	KEEP
Vehicle 393	SELL	KEEP	KEEP	KEEP	KEEP
Vehicle 394	KEEP	KEEP	KEEP	KEEP	SELL
Vehicle 395	SELL	KEEP	KEEP	KEEP	KEEP
Vehicle 396	SELL	KEEP	KEEP	KEEP	KEEP
Vehicle 397	SELL	KEEP	KEEP	KEEP	KEEP
Vehicle 398	KEEP	KEEP	KEEP	KEEP	KEEP
Vehicle 399	KEEP	KEEP	KEEP	KEEP	KEEP
Vehicle 400	KEEP	SELL	KEEP	KEEP	KEEP
Vehicle 401	KEEP	SELL	KEEP	KEEP	KEEP
Vehicle 402	KEEP	SELL	KEEP	KEEP	KEEP

Results-Part 1: Create Optimization Model

We changed the overall CO_2 emissions constraint, the tighter the emissions the higher the costs, but an initial gain of 700,000 $KgCO_2$ drop in emissions is achieved for 37,000 USD of cost increase.





Results-Part 2: Identify vehicle characteristics

We isolated the vehicle trips data based on cluster and load bin. We ran the algorithm on the sets that contain the most rows of data.

	Low Load	Medium Load	High Load	Overload
Route cluster 1	48	**145**	33	23
Route cluster 2	57	**299**		

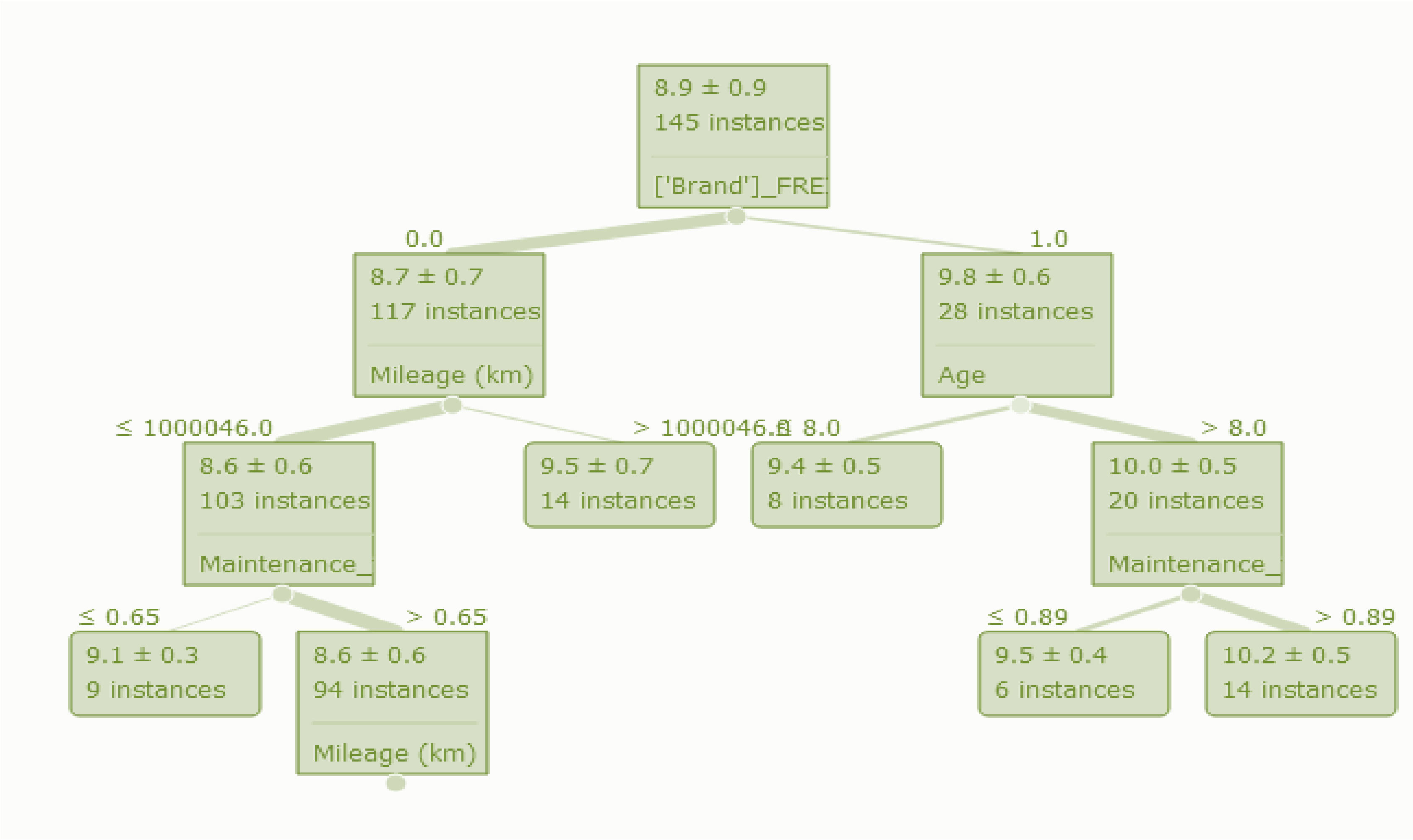
Table: Number of Vehicle trips in each cluster and load bin

Sample Data Structure

Vehicle ID	Brand	Engine Type	Age	Mileage (km)	Load bin	Cluster	Maintenance factor ($/km)	Fuel Factor (l/km)	CO_2 emissions ($KgCO_2/km$)
1825	KENWORTH	260 HP	15	266864	Medium	Cluster 1	2.84	3.45	9.02175
2509	FREIGHTLINER	260 HP	13	410681	Medium	Cluster 1	0.89	3.47	9.07405
6314	FREIGHTLINER	6.4 LTS.	8	477792	Medium	Cluster 1	15.12	3.11	8.13265
4468	INTERNATIONAL	260 HP	9	1005888	Medium	Cluster 1	7.1	3.39	8.86485
4471	INTERNATIONAL	260 HP	9	554411	Medium	Cluster 1	2.3	3.5	9.1525
4474	INTERNATIONAL	260 HP	9	1003713	Medium	Cluster 1	2.64	4.33	11.32295
4475	INTERNATIONAL	260 HP	9	1014421	Medium	Cluster 1	2.04	3.46	9.0479
4476	INTERNATIONAL	260 HP	9	1086055	Medium	Cluster 1	3.32	3.82	9.9893
4477	INTERNATIONAL	260 HP	9	318235	Medium	Cluster 1	3.25	3.23	8.44645
4478	INTERNATIONAL	260 HP	9	989293	Medium	Cluster 1	8.05	3.4	8.891

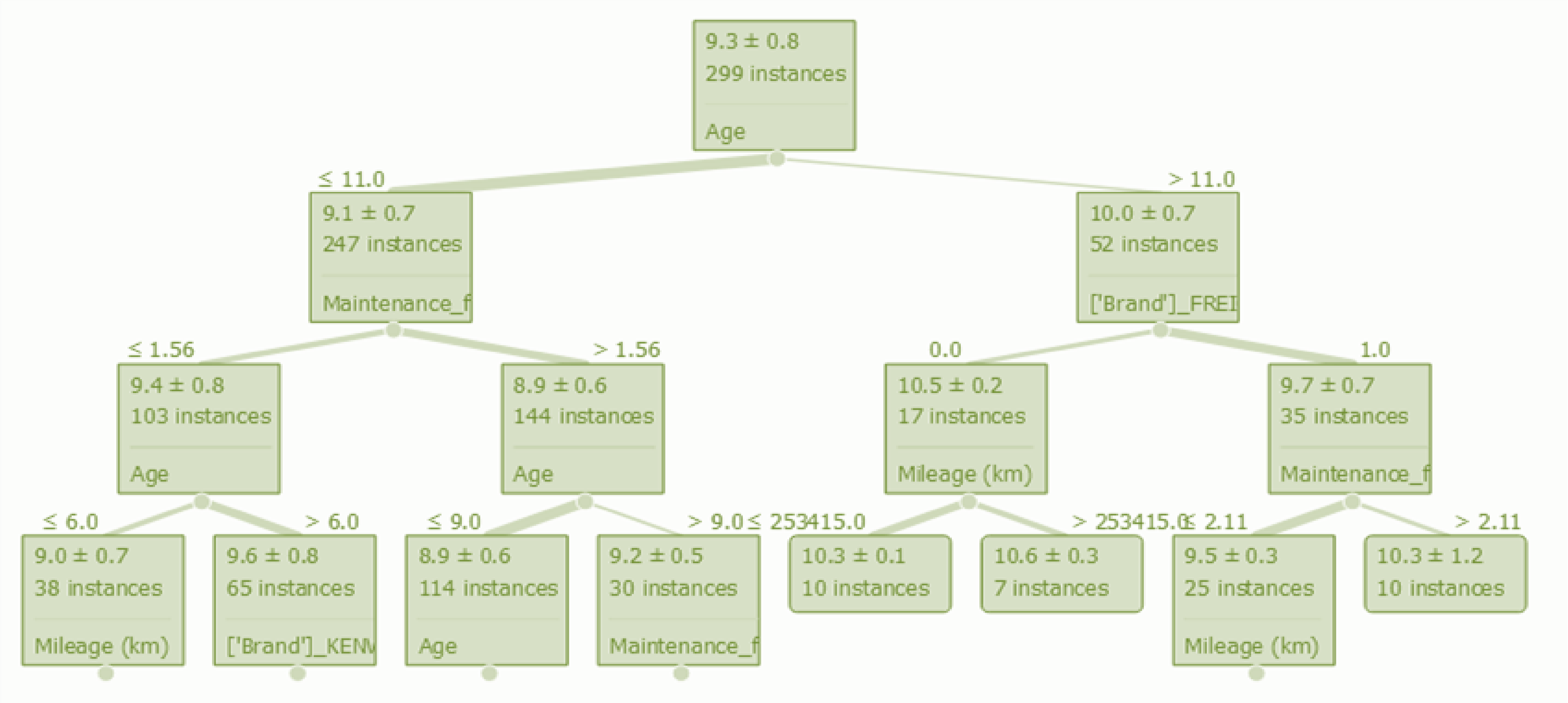
Results-Part 2: Identify vehicle characteristics

Cluster 1 -Medium Load: The first split of the tree is on the "brand" feature.



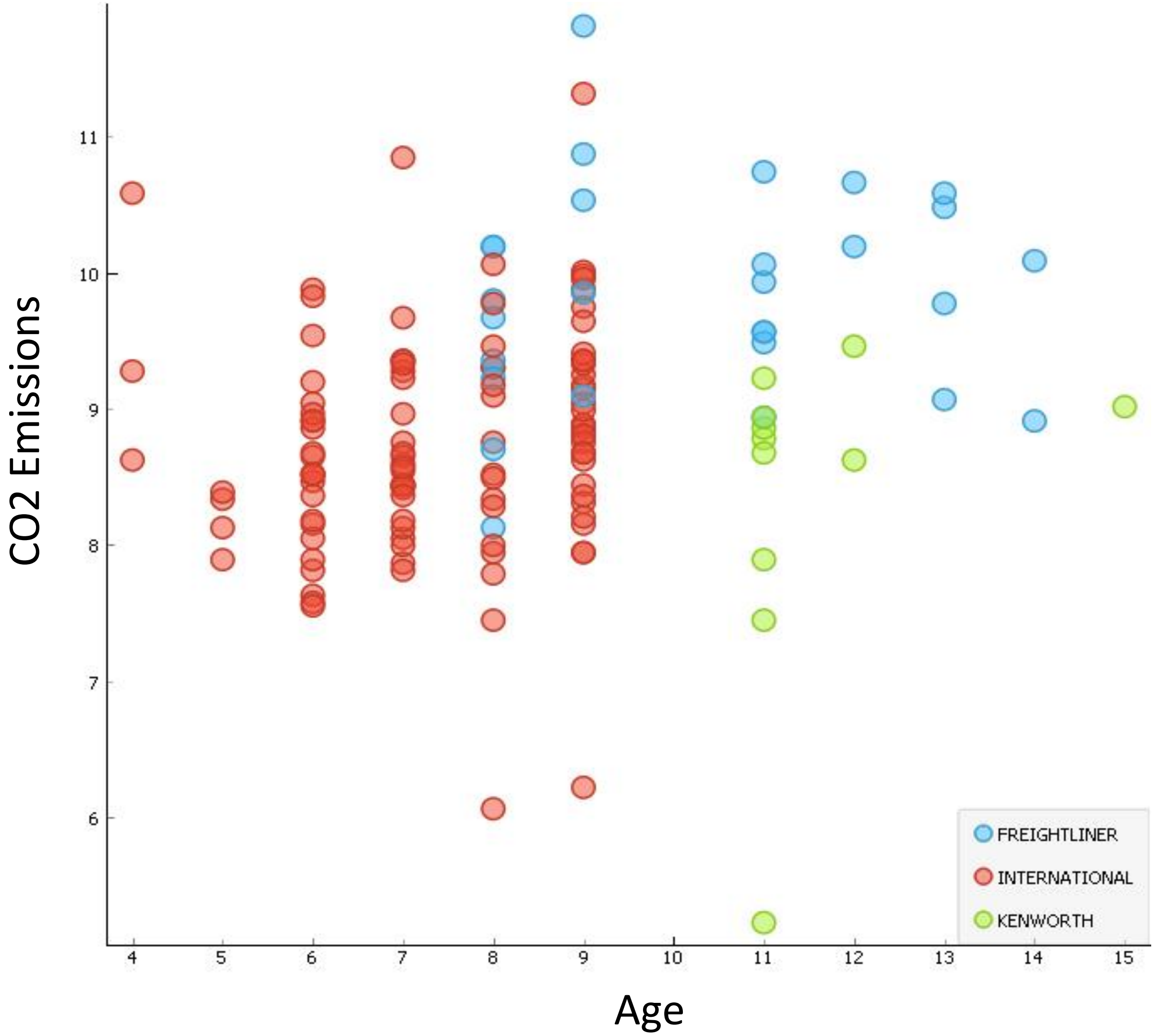
Results-Part 2: Identify vehicle characteristics

<u>Cluster 2 -Medium Load</u>: The first split of the tree is on the "age" feature.



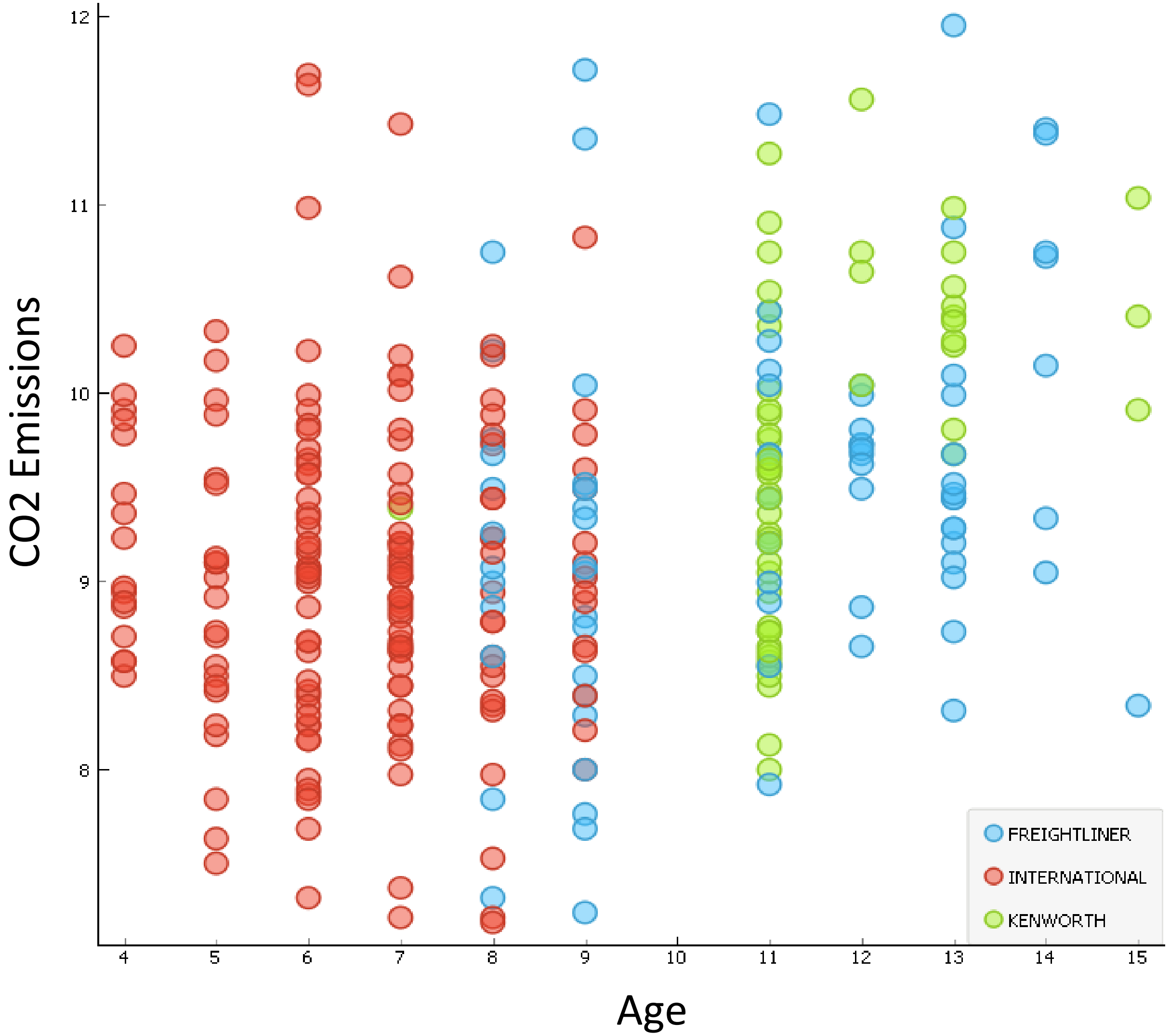
Results-Part 2: Identify vehicle characteristics

Cluster 1 -Medium Load:



Results-Part 2: Identify vehicle characteristics

Cluster 2 -Medium Load:



When making decision on new vehicles, detailed evaluation of brands should be done to ensure that new vehicles have better performance.

Managerial Implications

- Use the model for strategic replacement
- Centralize fleet decision
- Evaluation of procurement contracts for brand replacement

Operations

- Manage fleet investment capital
- Reduce operational costs

Financial

- Prepare for regulation compliance
- Run scenarios for CO2 emissions

Environment


“Be the change you want to see in the world”--Gandhi