GHG Protocol Scope 3 Emissions for a Top Retailer : Customer Travel Emissions to the Store

PURDUE UNIVERSITY | The Data Mine

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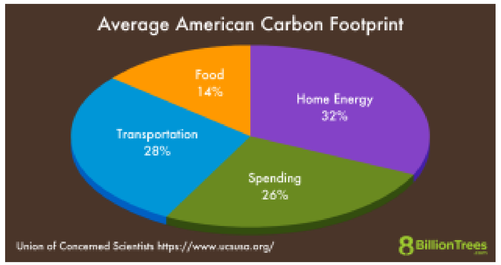
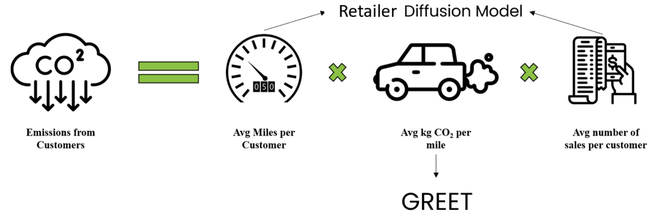


Background

One of the top retailers in USA aims to reduce their scope 3 emissions (emissions due to their entire supply chain). This, in part, includes emissions due customer travel to their stores (transportation is responsible for 28% of American carbon footprint). However, they do not have any data collected regarding customer vehicular profile or distance travelled by customers. Therefore, a model needs to be created that utilizes proxy datasets to help calculate the total emissions due to customer travel. Furthermore, vehicular emissions factors need to be determined based on the vehicular profile across the different states.



Avg Miles per Customer

- Utility for not going to the retail store:

$$u_0 = \alpha_0 + \alpha_1 \ln(\text{Pop den}) + \alpha_2 \ln(\text{Pop den})^2 + \overrightarrow{\beta} \times \overrightarrow{D}$$

- Utility for going to to the retail store :

$$u_i^j = (c_0 + c_1 \ln(\text{Pop den}))(\text{Distance}_{ij}) + \gamma(\text{Store Char})$$

- Probability for going to to the retail store :

$$p_l^j = \frac{1}{1 + e^{-u_o - u_l^j}}$$

- By multiplying the probability by the total population of the block, you can get an expected number of customers from block *l* to visit store *j*.
- Find the α's, β's, γ by regressing results on the actual customer count for each store.

Avg kg CO_2 per mile

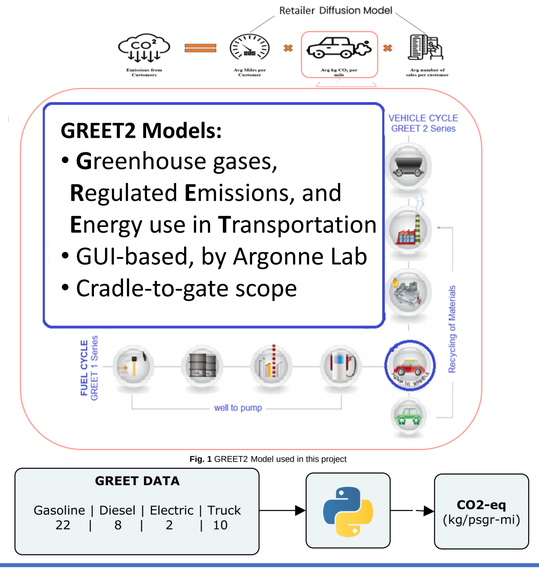


Fig. 1 GREET2 Model used in this project

Preliminary Results (Emissions Factor)

Table 1 Vehicle Emission Per Categories (kg/person-mile)

Type	Gasoline	Diesel	Electric	Bus	Total
CO2 (kg/mi)	0.276478	0.143837	0.02205	0.019705	0.46207
CH4 (kg/mi)	0.000396	0.00018	5.93E-05	3.12E-05	0.000667
N2O (kg/mi)	1.25E-05	6.86E-07	5.47E-07	4.01E-07	1.42E-05
PM2.5 (kg/mi)	1.23E-05	2.86E-06	2.22E-06	3.36E-07	1.77E-05

Table 2 Vehicle CO2-equivalent Emission Per Categories (kg/person-mile)

Type	Gasoline	Diesel	Electric	Bus	Total
CO2 (kg/mi)	0.276478	0.143837	0.02205	0.019705	0.46207
CO2-eq [CH4] (kg/mi)	0.009912	0.004491	0.001481	0.00078	0.016664
CO2-eq [N2O] (kg/mi)	0.003735	0.000204	0.000163	0.000119	0.004222
Grand Total	0.290125	0.148532	0.023694	0.020605	**0.482956**

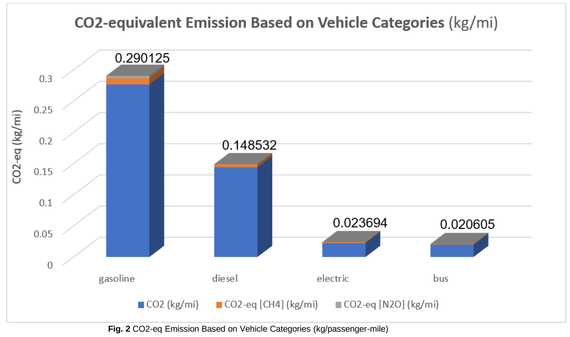


Fig. 2 CO2-eq Emission Based on Vehicle Categories (kg/passenger-mile)

- The GREET2 emission data for 42 vehicle categories, including 22 gasoline-fueled categories, 8 diesel-fueled categories, 10 bus categories, and 2 electric-fueled categories, are downloaded and used for the calculation [1].
- Python codes are utilized to concatenate and tag all the 42 vehicle emissions, making it easier to pull relevant data points for emissions calculation.
- The average bus occupancy rate of 12.74, taken from PA data, is used to estimate the number of passengers traveling on buses to the retail store [2].

Preliminary Results (Distance Travelled)

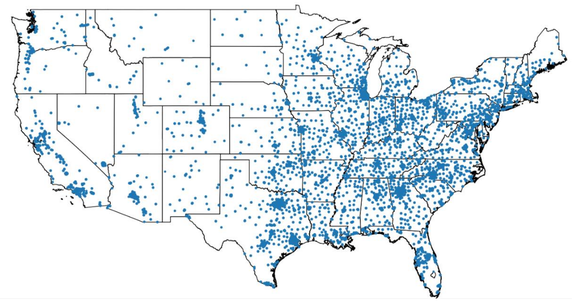


Fig. 3 Retailer Location in the US

Fig. 3 shows the locations for the retailer across the contiguous United States. Each dot is also sized according to the aggregate distance travelled for that particular retailer. As you can see, the urban areas are denser and overrepresent driving compared to rural areas, where even though the distance might be larger, the number of people is too low to match the aggregate driving distances in the urban areas.

Future Goals

- To develop a detailed vehicular profiling for the US or specifically for personal grocery transportation.
- To find the US or state's bus occupancy, which could provide more accurate data on the number of passengers traveling on buses.
- Validate data across different datasets and correct discrepancies. Once validated, create regression model via R and send to corporate mentor for regression. Once parameters are received, create an accurate model for driving distances for each store.

Acknowledgement and References

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References

[1] EPA, "Greenhouse Gas Inventory Guidance: Direct Emissions from Mobile Combustion Source," EPA, 2020. [Online]. Available: https://www.epa.gov/sites/default/files/2020-12/documents/mobileemissions.pdf

[2] US Department of Transportation, "Developing a Statistically Valid and Practical Method to Compute Bus and Truck Occupancy Data," US Department of Transportation, 2019.

[3] O. US EPA, "Latest Version of MOtor Vehicle Emission Simulator (MOVES)," May 10, 2016. https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves (accessed Apr. 05, 2023).