The Cost of Moving Food

Exploring Food Sustainability Through the Lens of Transport

Time, Resources, Environmental Impact and Price

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Data Analytics Capstone Project
Nashville Software School
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Motivation - Why I care about this topic

- “Food” is a subject of great interest and passion for me: not just recipes and foodie-trends, but also in the topics of gastro-anthropology, socio-ethics, accessibility, and sustainability

- I desire to live a more deliberately sustainable lifestyle. To accomplish this, I need to be more informed about the impact that the choices that I make have on the world around me

Motivation - Why you should care about this topic

- Food systems (including production, processing, and transport) are one of the leading sources of global greenhouse gas emissions, accounting for nearly 35% of the global total

* Sustainable healthy diets - Guiding principles. Food and Agriculture Organization of the United Nations and World Health Organization, 2019.

- Sustainability is a hot topic of conversation right now within business and commercial institutions, academic study, government policy, geo-politics, and public interest

Data Sources

- U.S. Department of Transportation (National Freight Statistics)
- U.S. Surface Transportation Board (Rail Service Data)
- U.S. Department of Energy (Motor Vehicle Mileage, Fuel Consumption, and Fuel Economy)
- U.S. Department of Energy (Short-Term Energy Outlook, December 2011)
- U.S. Department of Energy (Carbon Dioxide Emissions Coefficients by Fuel)
- The Geography of Transport Systems, by Jean-Paul Rodrigue (Fuel Consumption by Containership Size and Speed)
- The Conservation Fund (Moving Freight: Economy and Atmosphere)
- The National Air and Space Museum (How Things Fly)

Data Questions

- How fast does cargo travel via different methods?
- How much fuel does it take to move cargo by these methods?
- How much CO_2 is produced to move this cargo?
- How much is spent (USD) in fuel to move our food-centric cargo?

Approach

- Find and collect data
  - Most data found in CSV format from US Dept. of Transportation & US Dept. of Energy
  - Some data found in published graphs or charts in US.gov publications, or cited by US.gov, United Nations, or peer-reviewed publications
    - Charts converted to csv using Adobe Acrobat
    - Graphs converted to csv using GetData Graph Digitizer
- Clean data
  - Drop unneeded columns and irrelevant rows
  - Rename select columns and variables for clarity
  - Reshape datasets into more useable arrangements
  - Fill gaps with cited data from relevant articles
- Exploratory data analysis
  - Understand the data
  - Build calculated columns and queries based upon the data available to find the answers to my data questions
- Data visualization
  - Isolate important metrics within my data, and convert the information into easily understandable visuals
  - Formatting and editing of visuals to maintain thematic consistency
  - Assembling visuals into a short presentation

Challenges



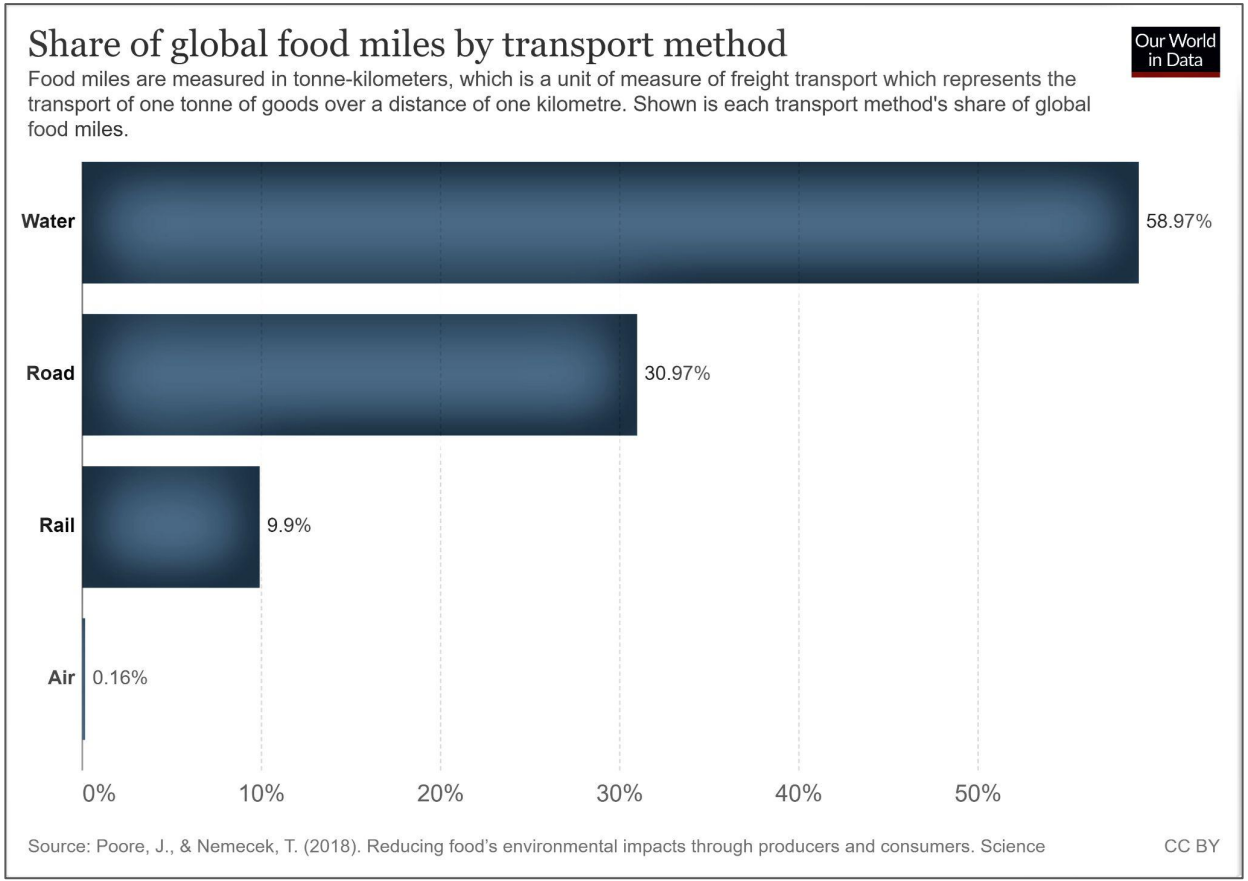

- Variable diversity within the scope of my data questions
  - Many of my questions center on how much fuel is consumed when moving cargo, but that depends upon the kind of fuel being used, the kind of vessel using it, and how much total weight that vessel is carrying
  - The data can be further complicated by a nearly infinite amount of sub-variables such as idling times, age and maintenance of the vessel, individual company policies, urban congestion, and the weather. These were not factors that I included in my data analysis, which necessitates an unknown measure of inaccuracy in my findings

- Variable diversity within the data itself
  - Some fuel measurements were listed in tons, others in gallons. And different types of fuel weigh different amounts
  - Fuel consumption levels were sometimes provided by amounts of fuel consumed by day, other times by hour, and other times by distance
  - Speed data was listed in kilometers per hour, miles per hour, and nautical knots across different data sets and different transportation types
  - The weight of a shipping container, or how much weight a transport vessel is carrying, can vary significantly depending upon what is in the container, necessitating a consistent method of determining averages in cargo weights across my datasets

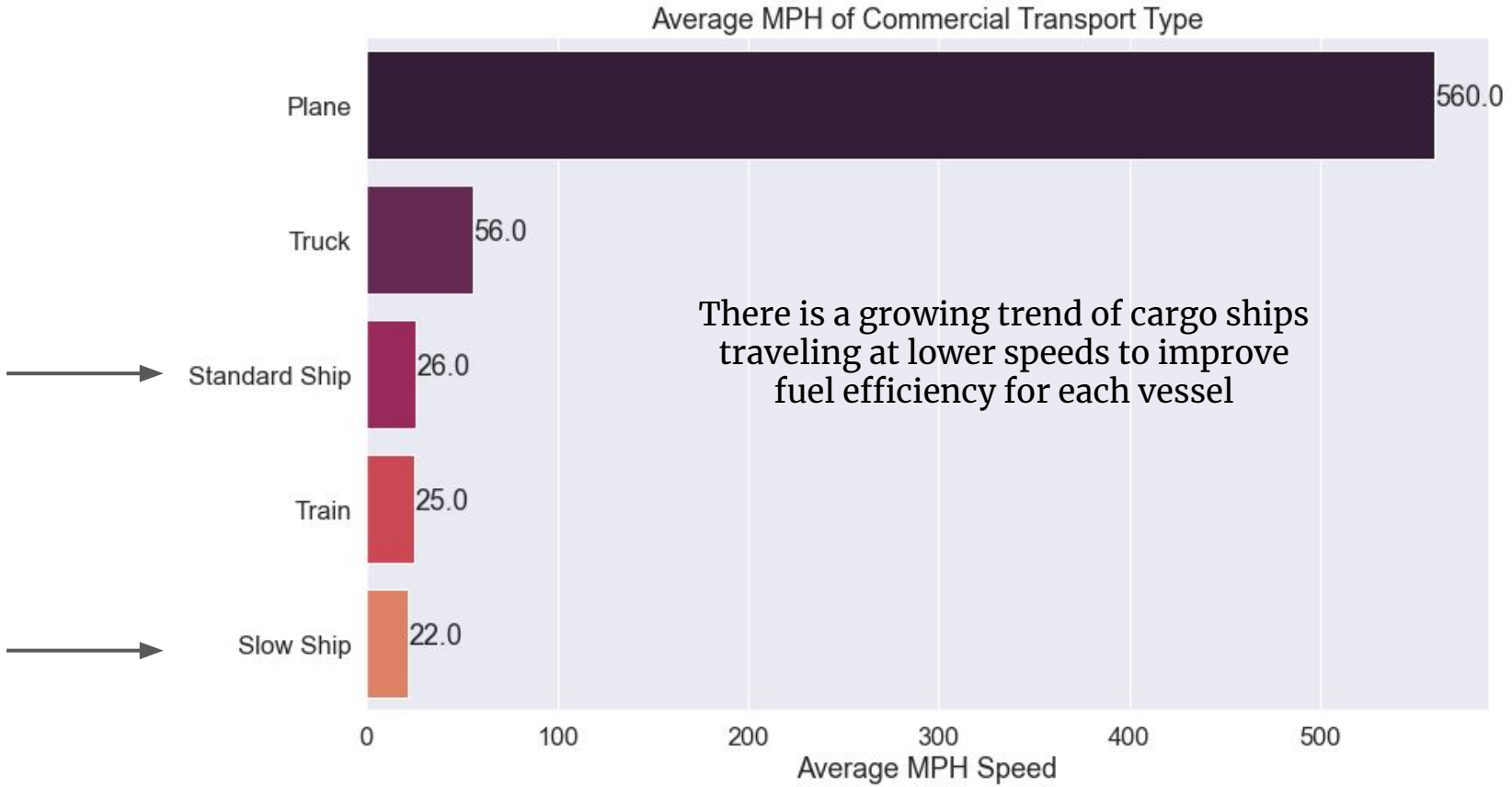
Methodology

- **Convert all speeds to miles per hour (MPH)**
- **Convert all fuel measurements to gallons**
- **Determine average weights for cargo loads - convert all to tons**
  - For **ships**, ship size was given in ranges of standard TEU measurements - Twenty-foot Equivalent Unit, the size of a cargo container.
    - Maximum gross mass of dry goods (which excludes non-packaged liquid food cargo) per TEU is 52,910 lbs (5,140 container + 47,770 cargo). I used the total maximum weight of a TEU times the mean TEU capacity per ship-size-class to determine average ship cargo weights.
    - I dropped the largest size category of my dataset - 10,000+. As I had no information on what the upper ceiling was on that range, it was impossible to guess average cargo loads with any degree of accuracy.
  - For **planes**, most cargo planes are the same size and make as passenger planes, and the average size plane (Boeing 737) carries an average weight of 45,000 lbs of cargo *Smithsonian National Air and Space Museum
  - For **trucks**, my data provided maximum truck carrying weights (in lbs) by the old truck-class system (class 1-8), but my truck fuel consumption data was given using a newer government classification system of 3 categories. To determine an average cargo load of the new system, I filtered the old 8-class system into the new 3-category system and used the mean of the lower maximum weight plus the higher maximum weight within that category as the average cargo weight for trucks within that category.
  - For **trains**, I found the average non-liquid cargo load stated clearly within a published article as 30,000 tons per train
- **Filter all information through the lens of efficiency via ton-mile**
  - How far a ton of cargo can travel using the different methods
  - Calculated by multiplying how much weight a vessel is carrying by the miles-per-gallon of that vessel
  - The impact of different methods of transport, measured by 1-ton of cargo

Where to start:
How does food get from the source to the market?



How fast does food travel by these different methods?



There is a growing trend of cargo ships traveling at lower speeds to improve fuel efficiency for each vessel

How fuel efficient are these modes of transport?

~~How many miles per gallon (MPG) does each type get?~~

IT DEPENDS

	Smaller Truck	10 tons	10 mpg	2 gallons 10 mi.
✓	Larger Truck	20 tons	7 mpg	2 gallons 14 mi.

How fuel efficient are these modes of transport?

How many miles can a ton of cargo travel on a gallon of fuel (on average)?

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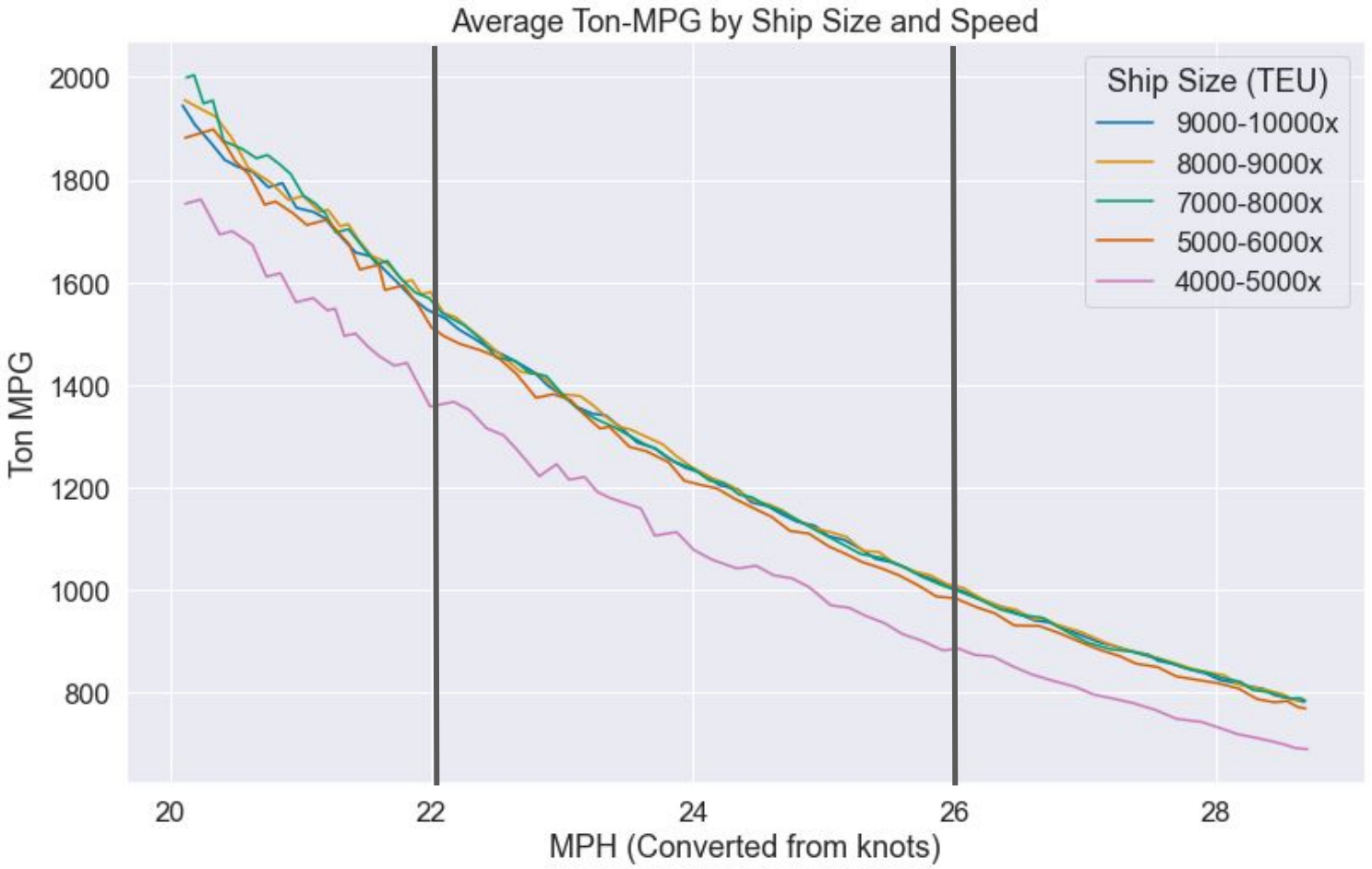

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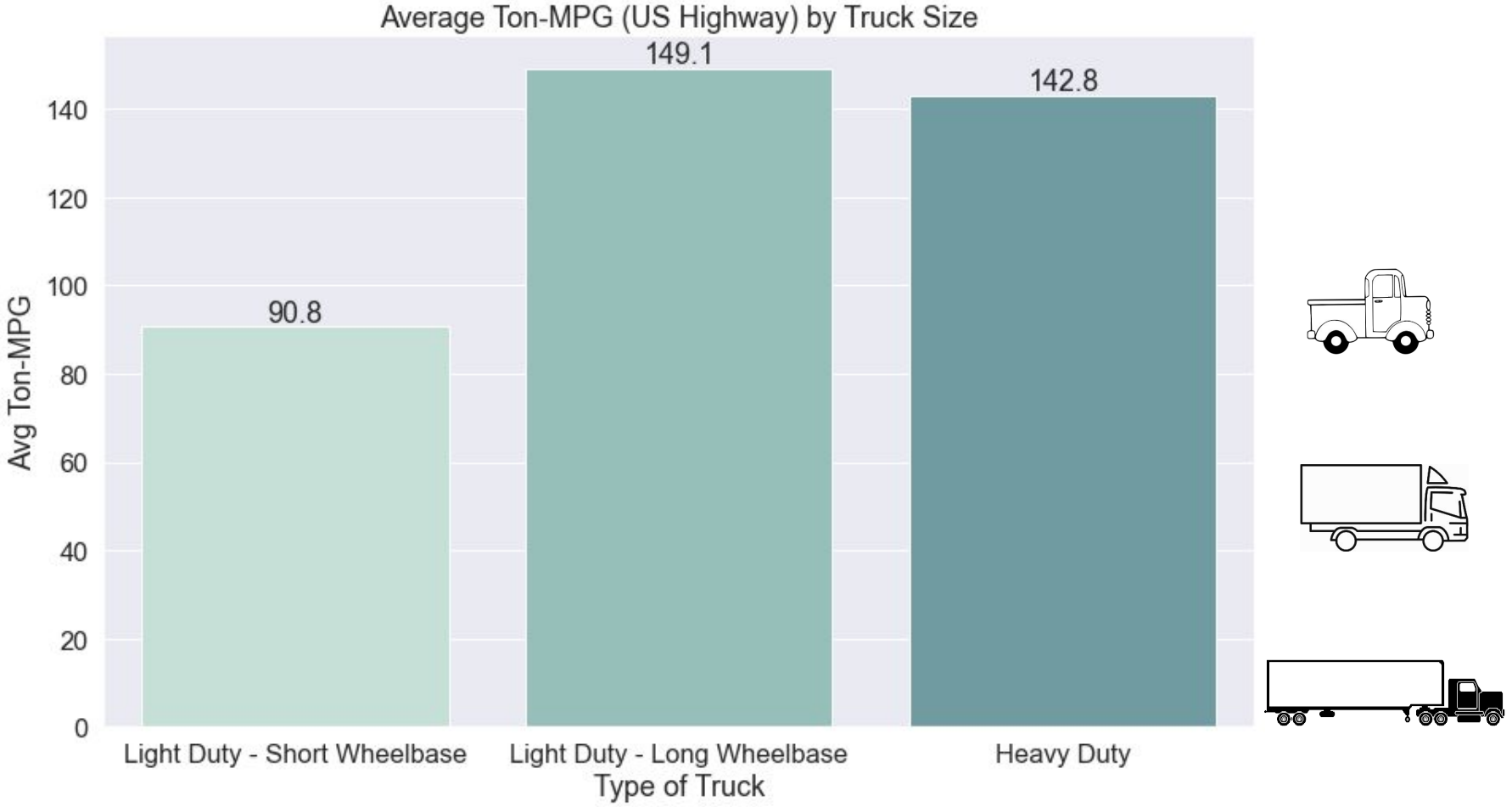

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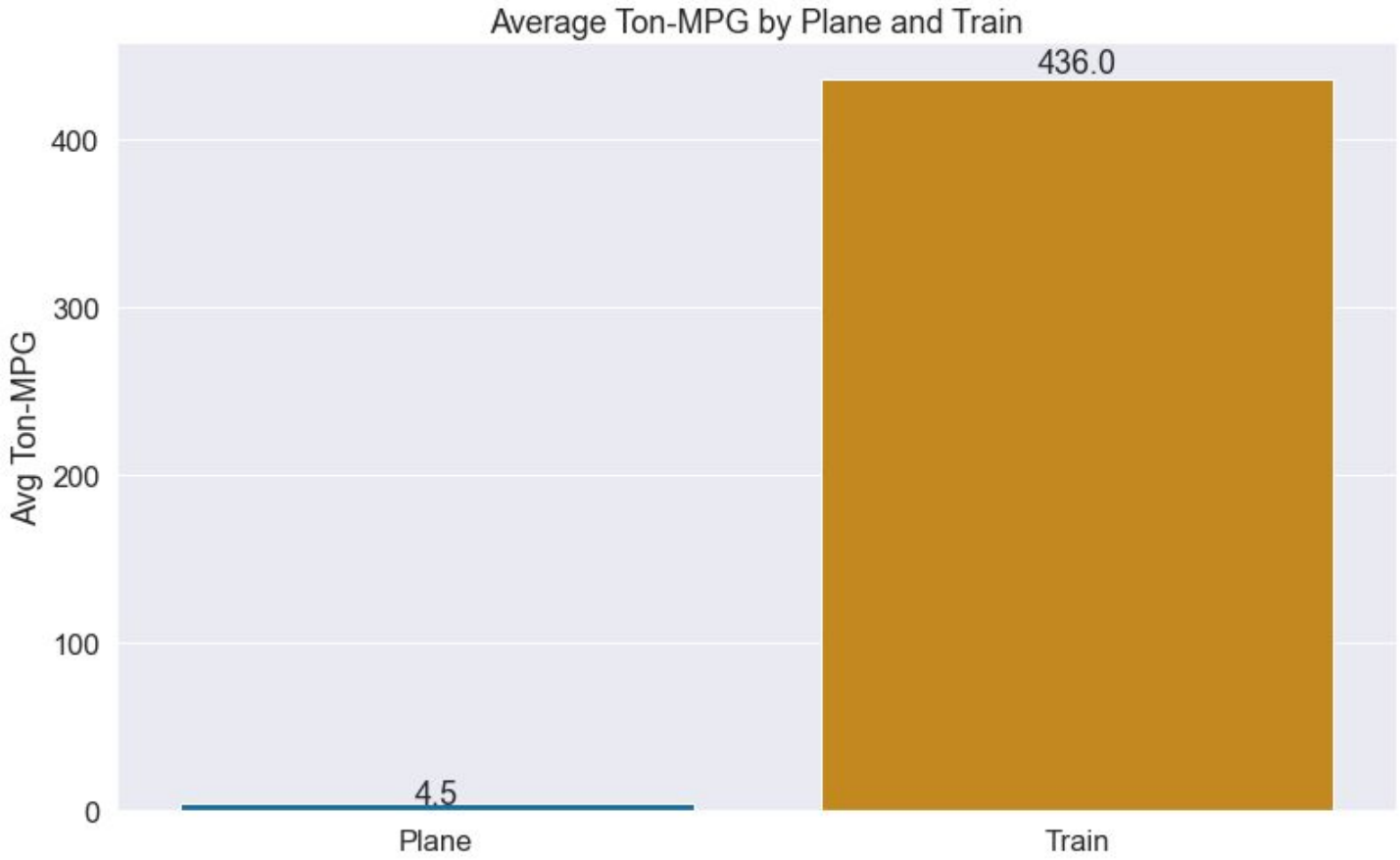
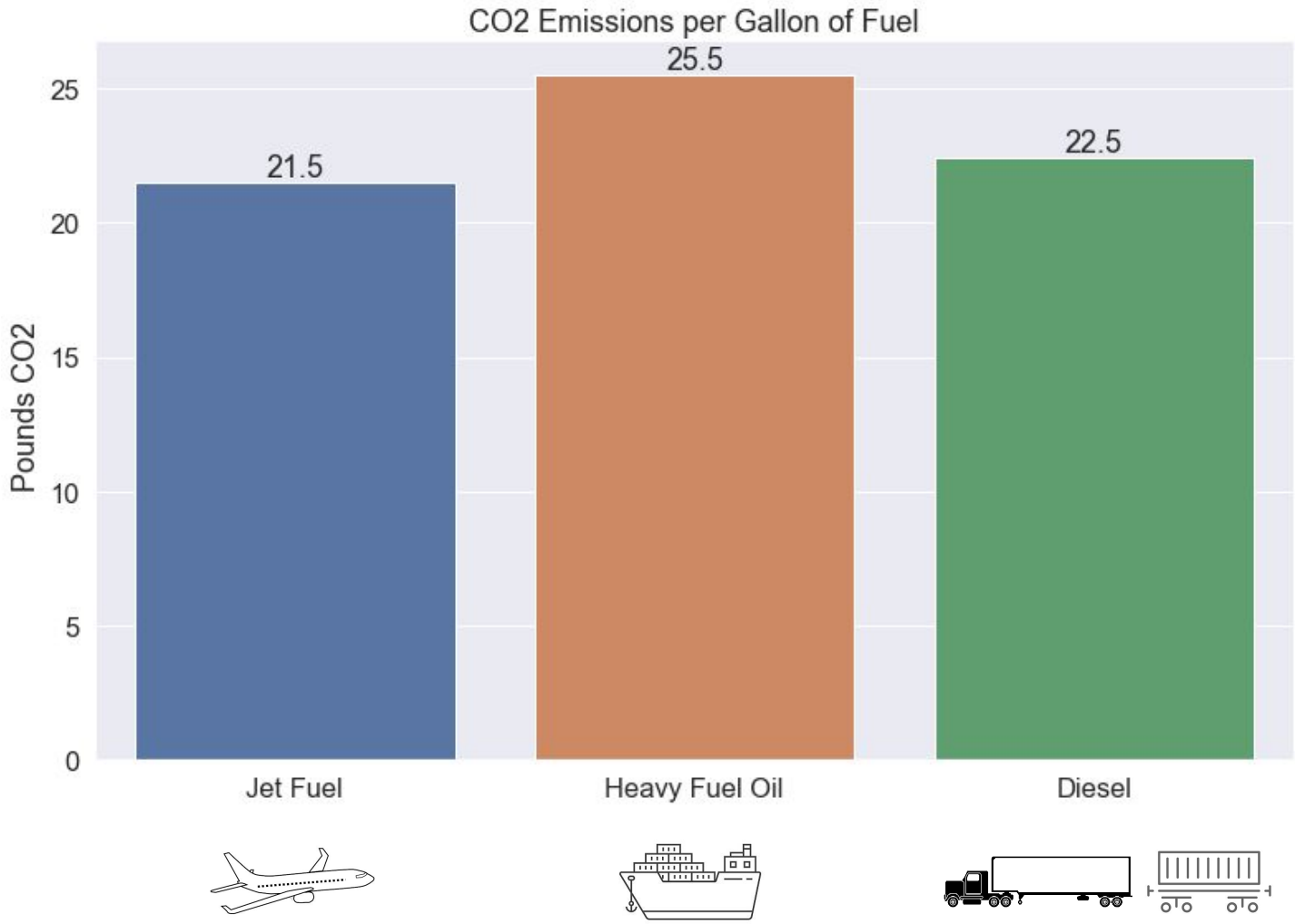


What kind of environmental impact do these different methods of transport have?

- The most direct impact when discussing transport, are greenhouse gas emissions from fuel consumption
- Fuel = carbon = CO_2
- For every pound of carbon burned, three pounds of CO_2 are produced


CO2 Emissions per Gallon of Fuel
Pounds CO2
0
5
10
15
20
25
21.5
25.5
22.5
Jet Fuel
Heavy Fuel Oil
Diesel

How much does fuel cost?

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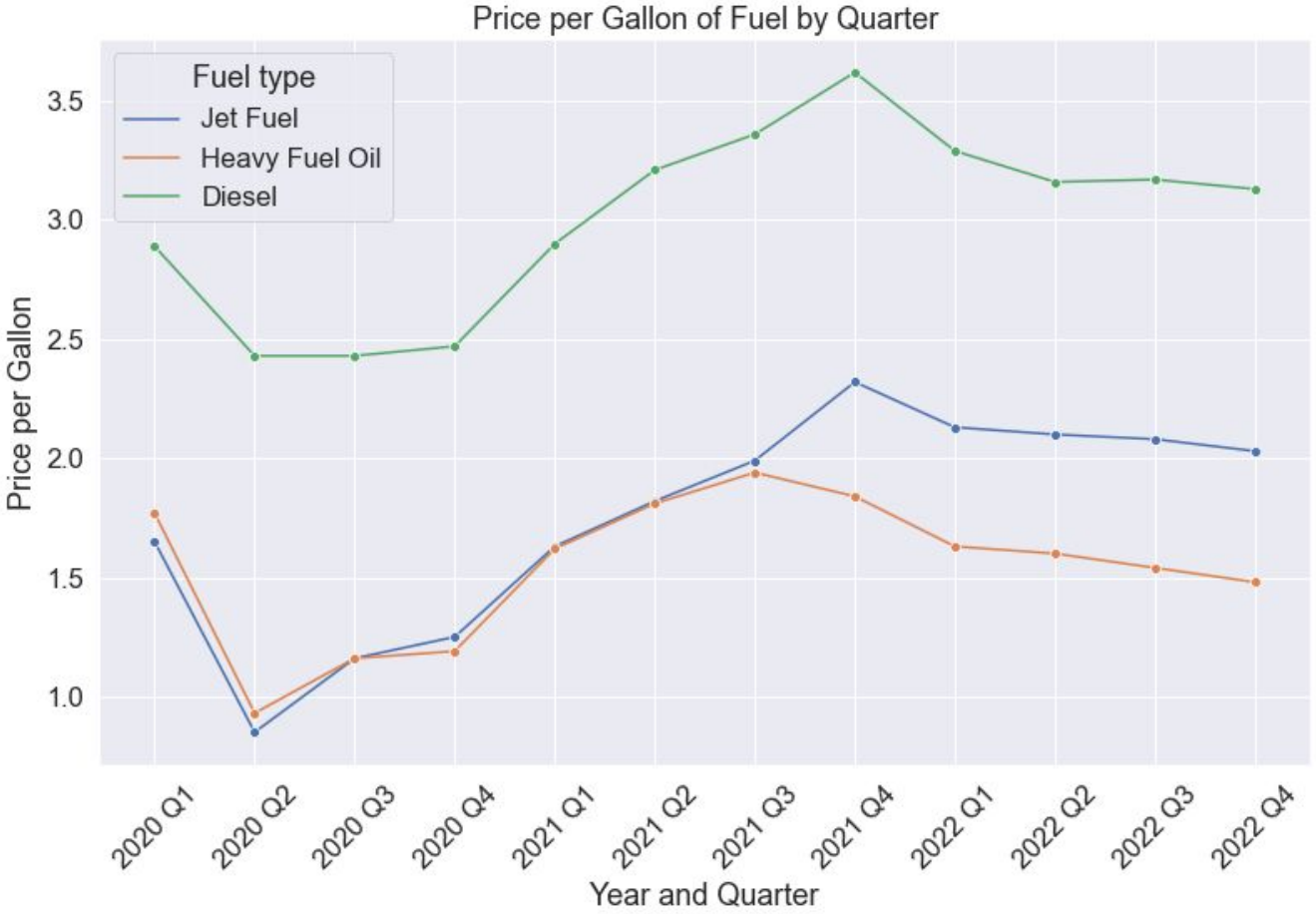

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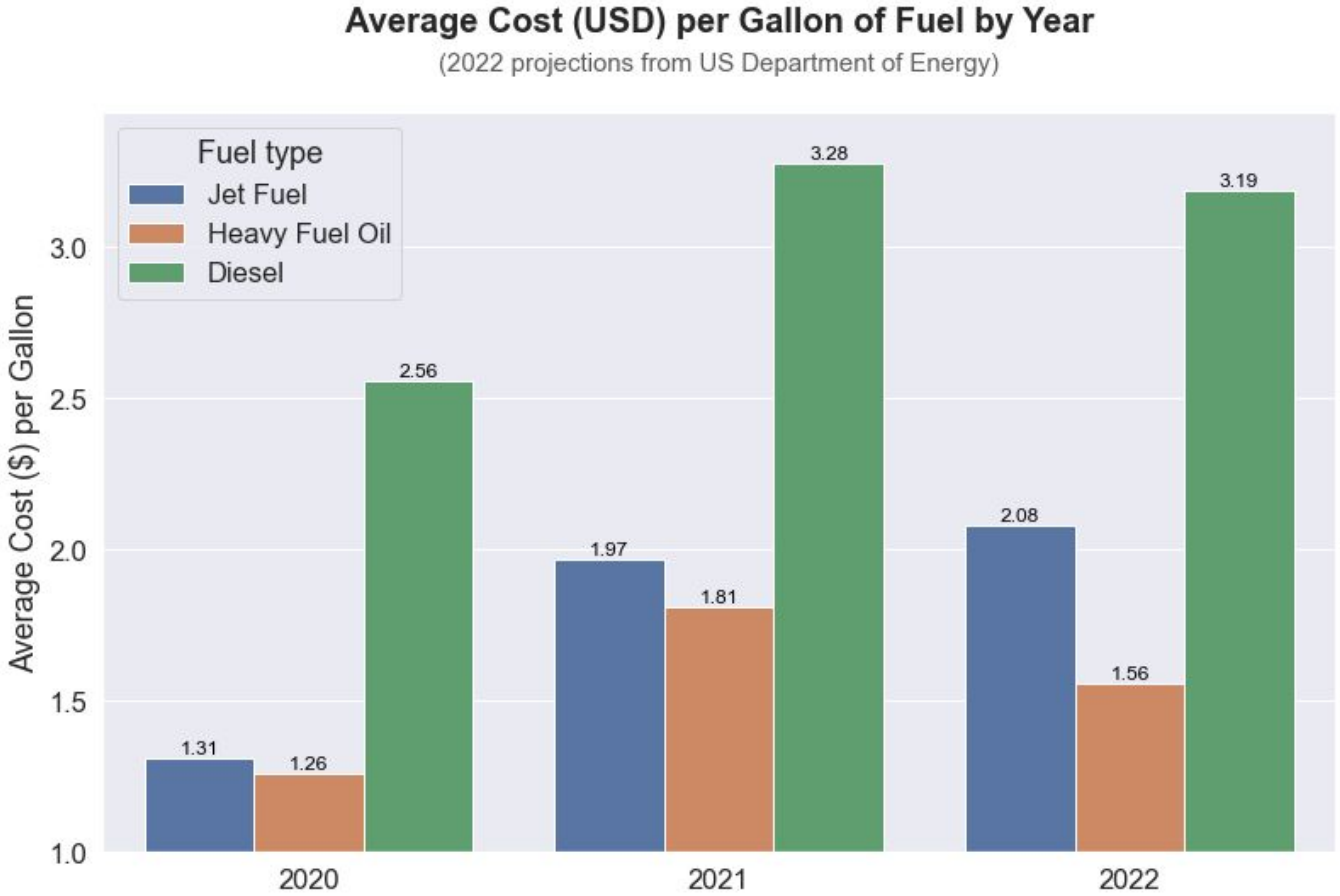


What does this all mean?

How is all this data relevant to any decisions I make?

Leopold Center for Sustainable Agriculture
Iowa State University, 2001
"Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emissions"

Average Distances from Farm to Market

Terminal Market vs. Ferry Plaza Farmers Market

Apples: 1,555 miles vs. 77 miles

Tomatoes: 1,369 miles vs. 117 miles

Grapes: 2,143 miles vs. 134 miles

Beans: 766 miles vs. 101 miles

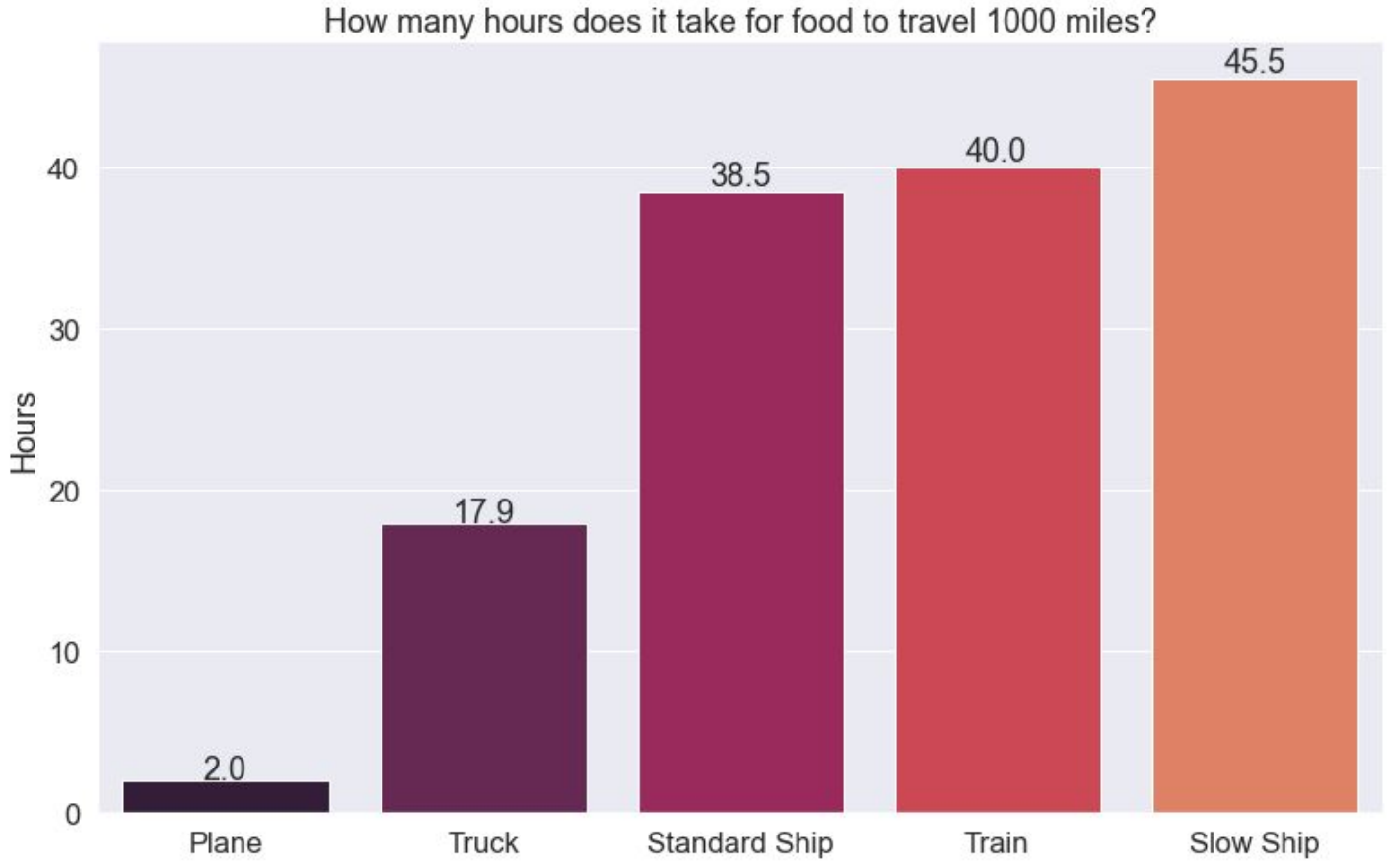
Peaches: 1,674 miles vs. 173 miles

Winter Squash: 781 miles vs. 98 miles

Greens: 889 miles vs. 99 miles

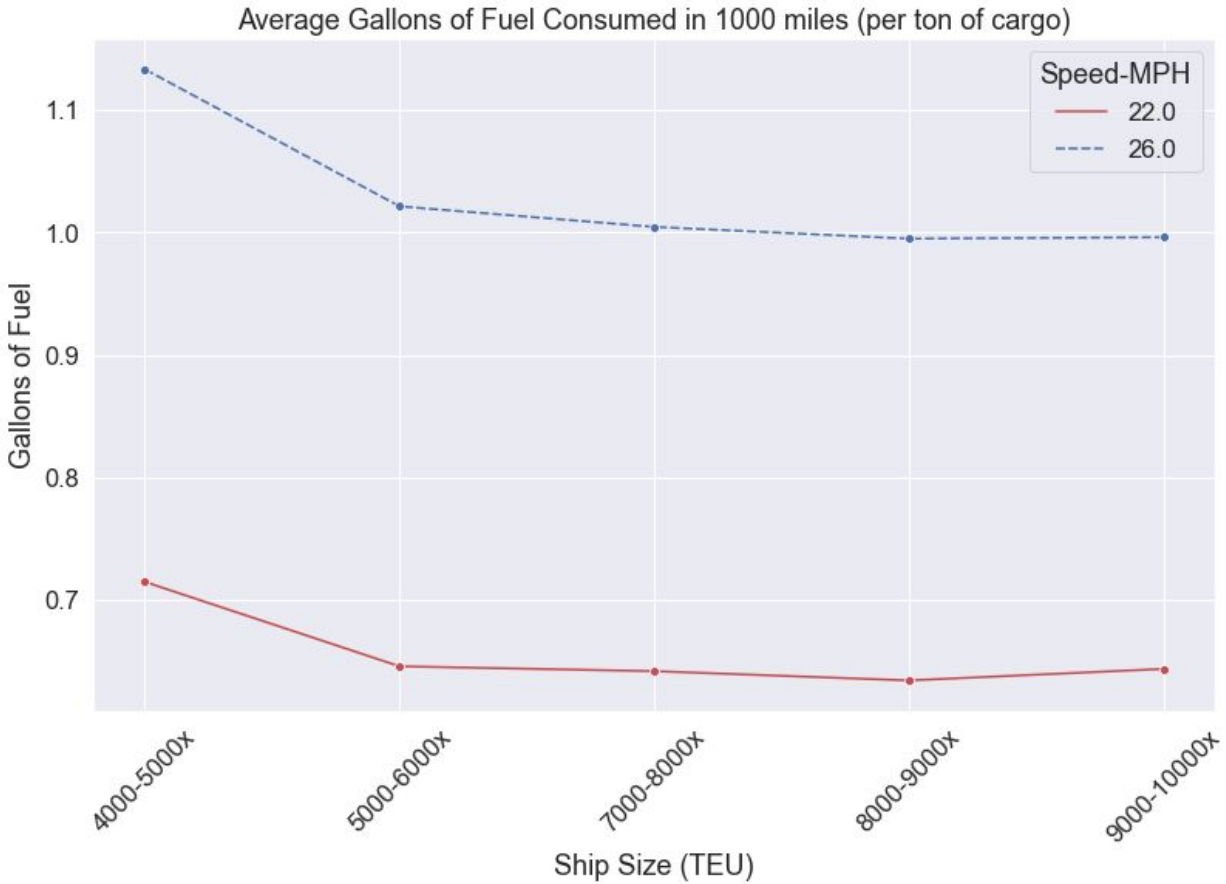
Lettuce: 2,055 miles vs. 102 miles

How much time does it take food to travel 1000 miles?



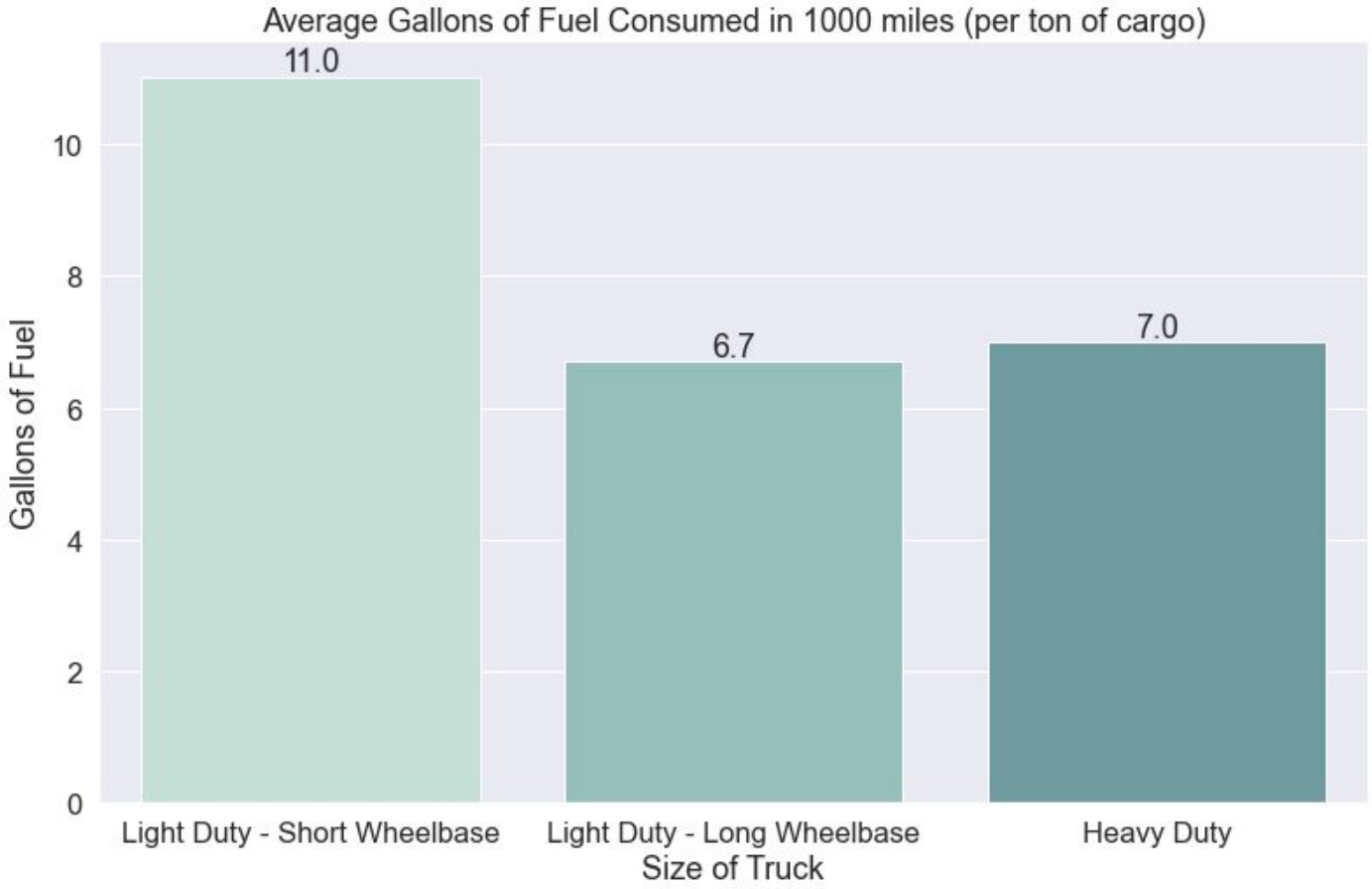
How many gallons of fuel does it take for food to travel 1000 miles?

By Ship



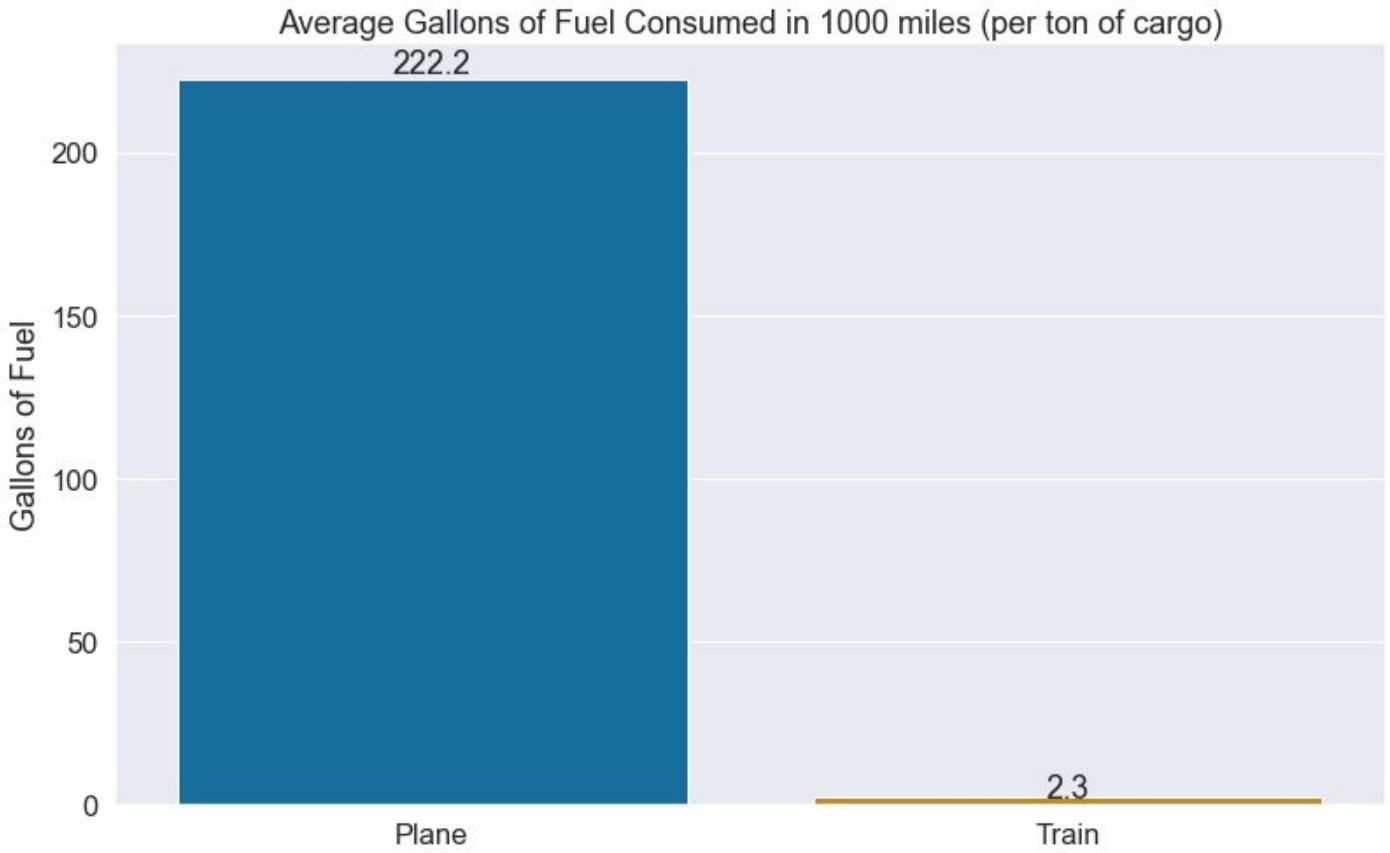
How many gallons of fuel does it take for food to travel 1000 miles?

By Truck

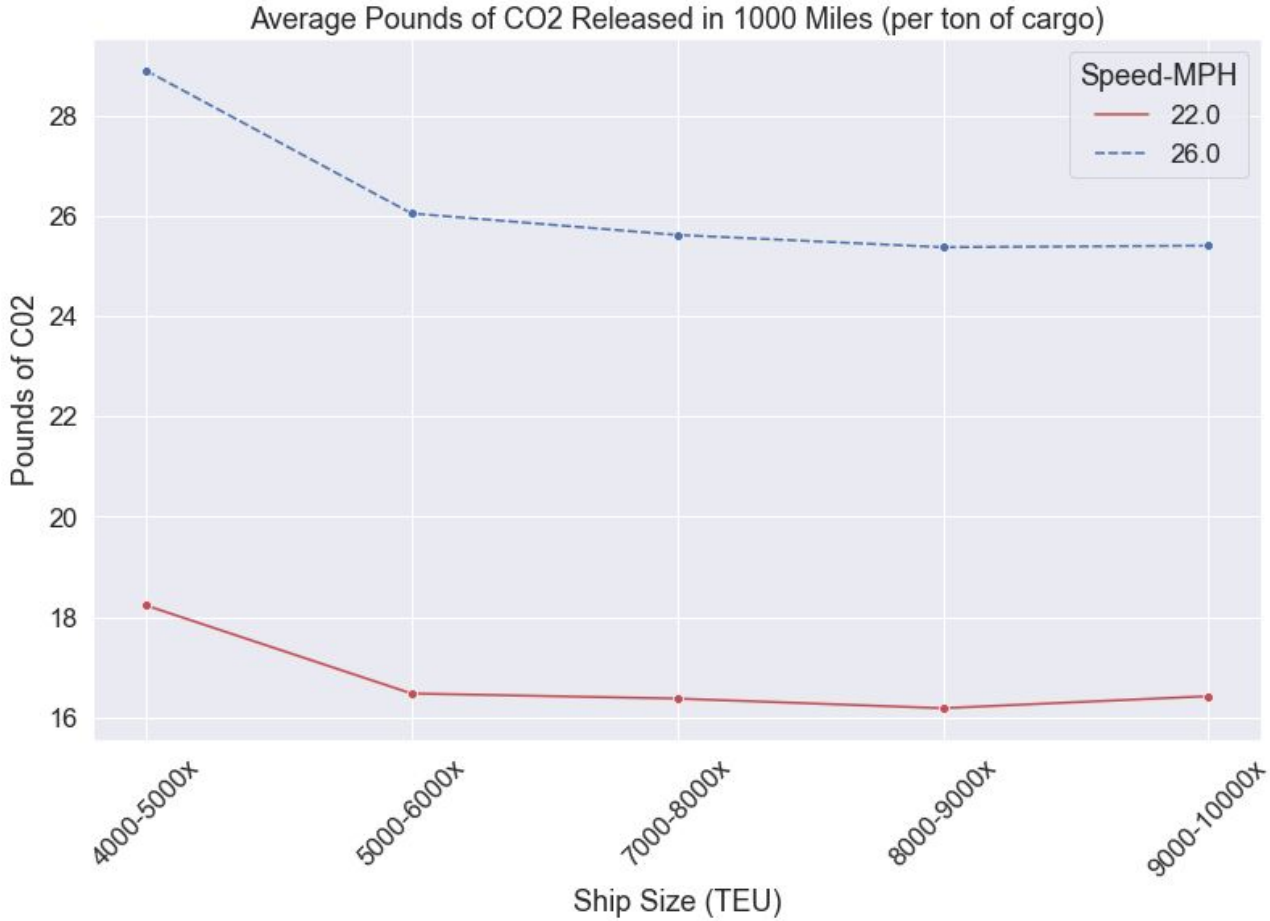


How many gallons of fuel does it take for food to travel 1000 miles?

By Train or Plane



How many pounds of CO2 are produced to move food 1000 miles?



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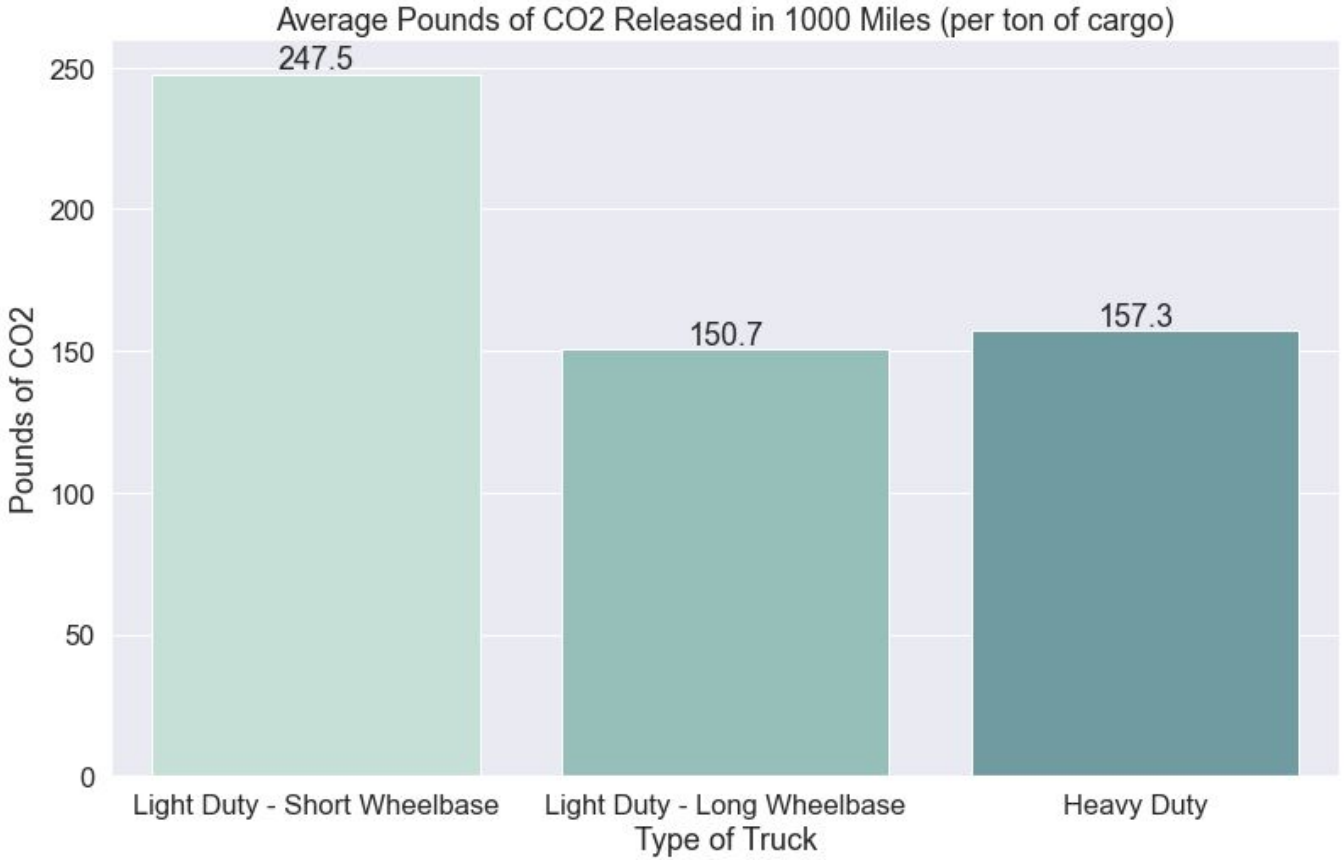
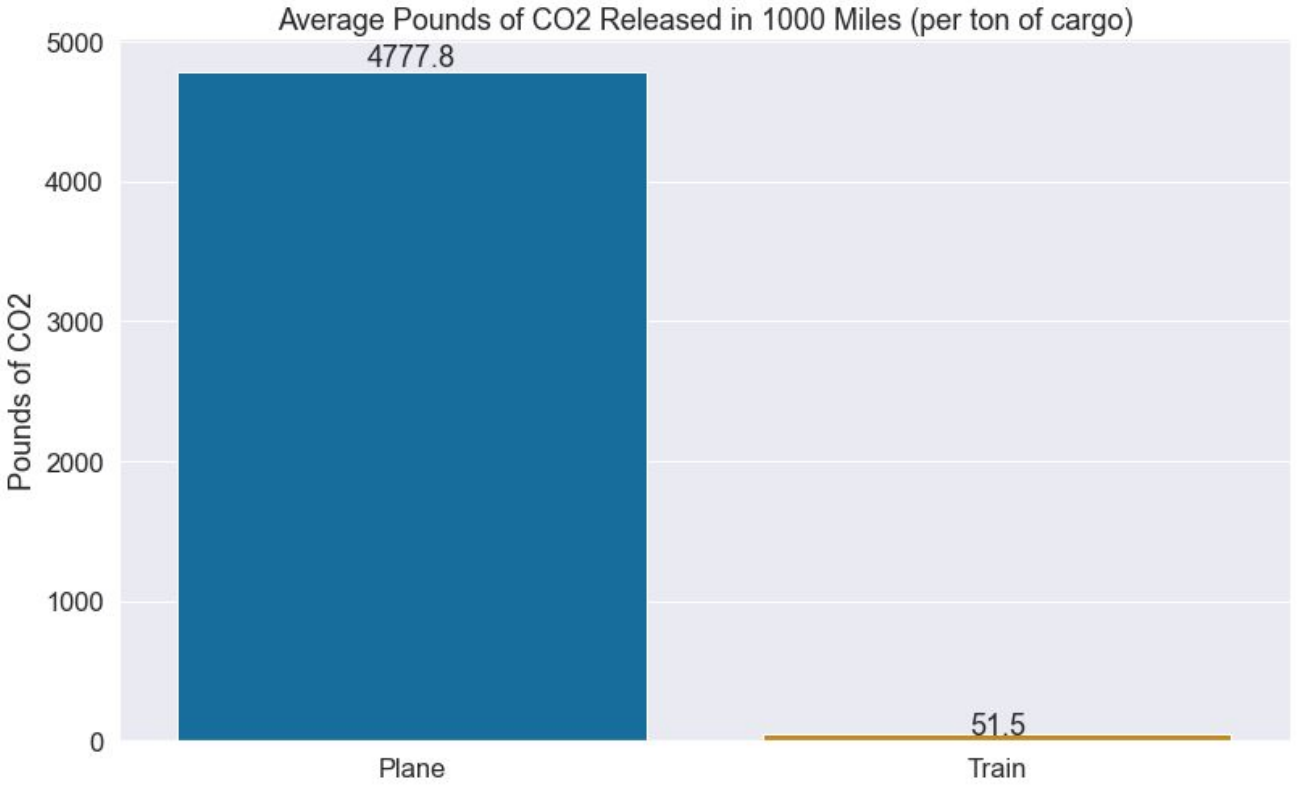


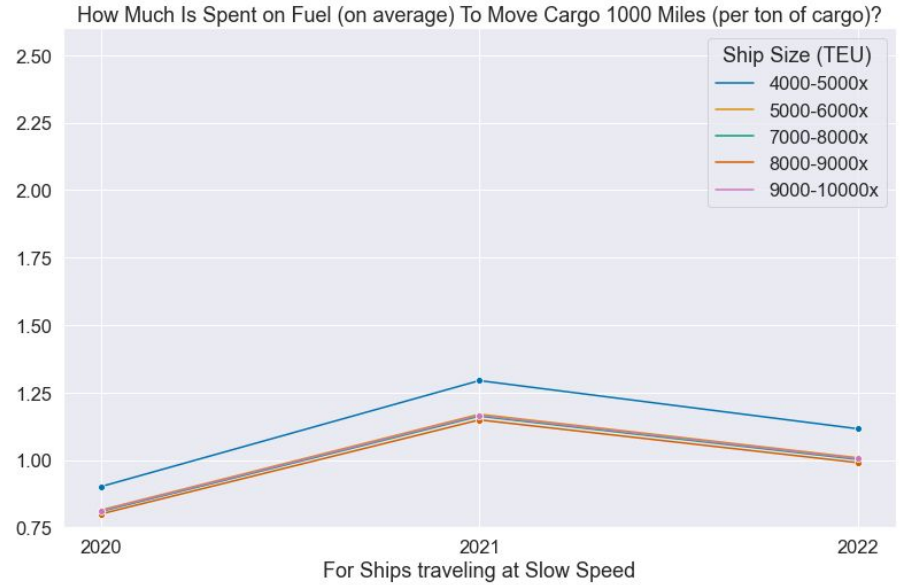
By Truck

How many pounds of CO2 are produced to move food 1000 miles?



By Plane or Train

How much is spent on fuel to move food 1000 miles?

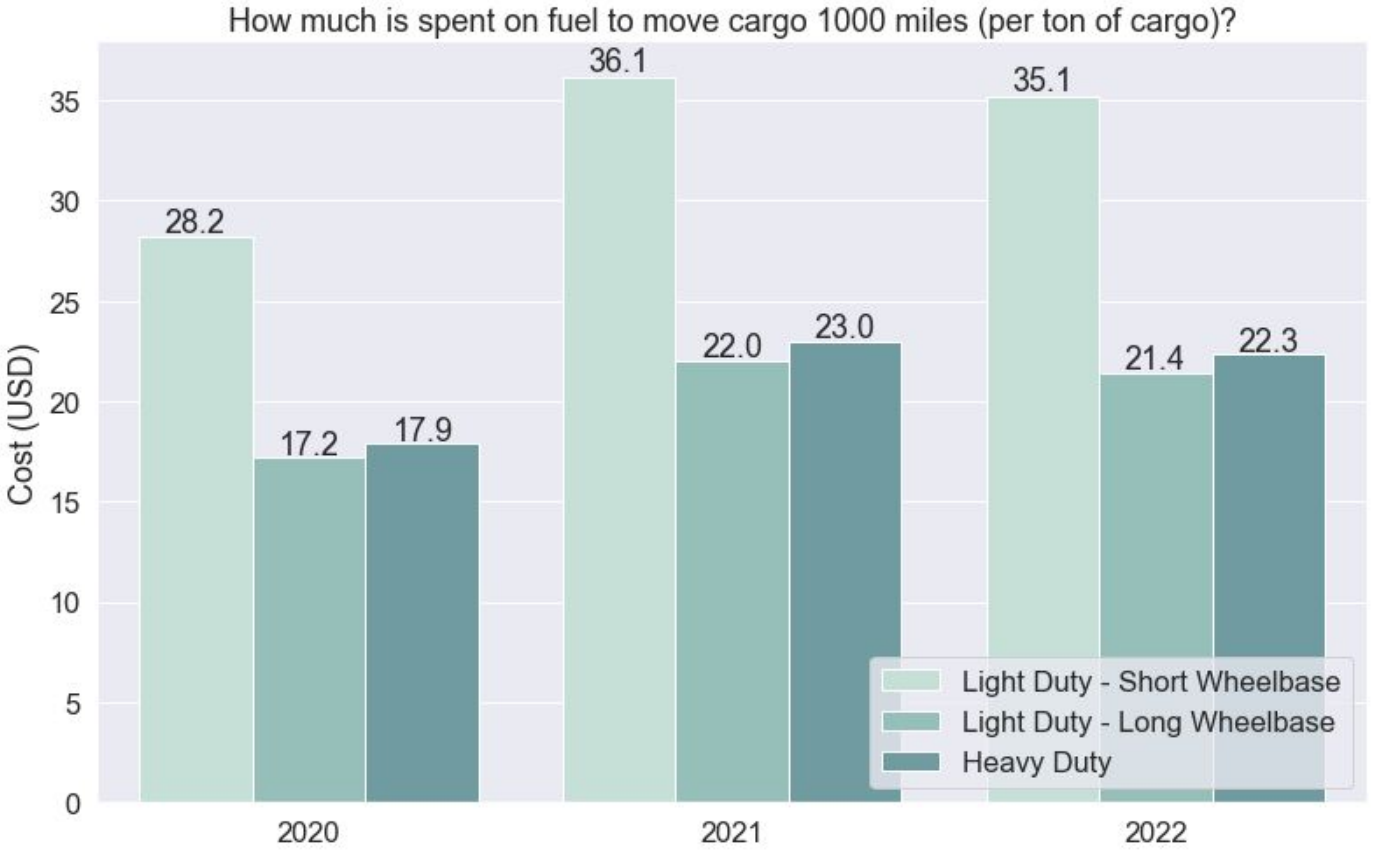


Fast Ship

Slow Ship

How much is spent on fuel to move food 1000 miles?

By Truck



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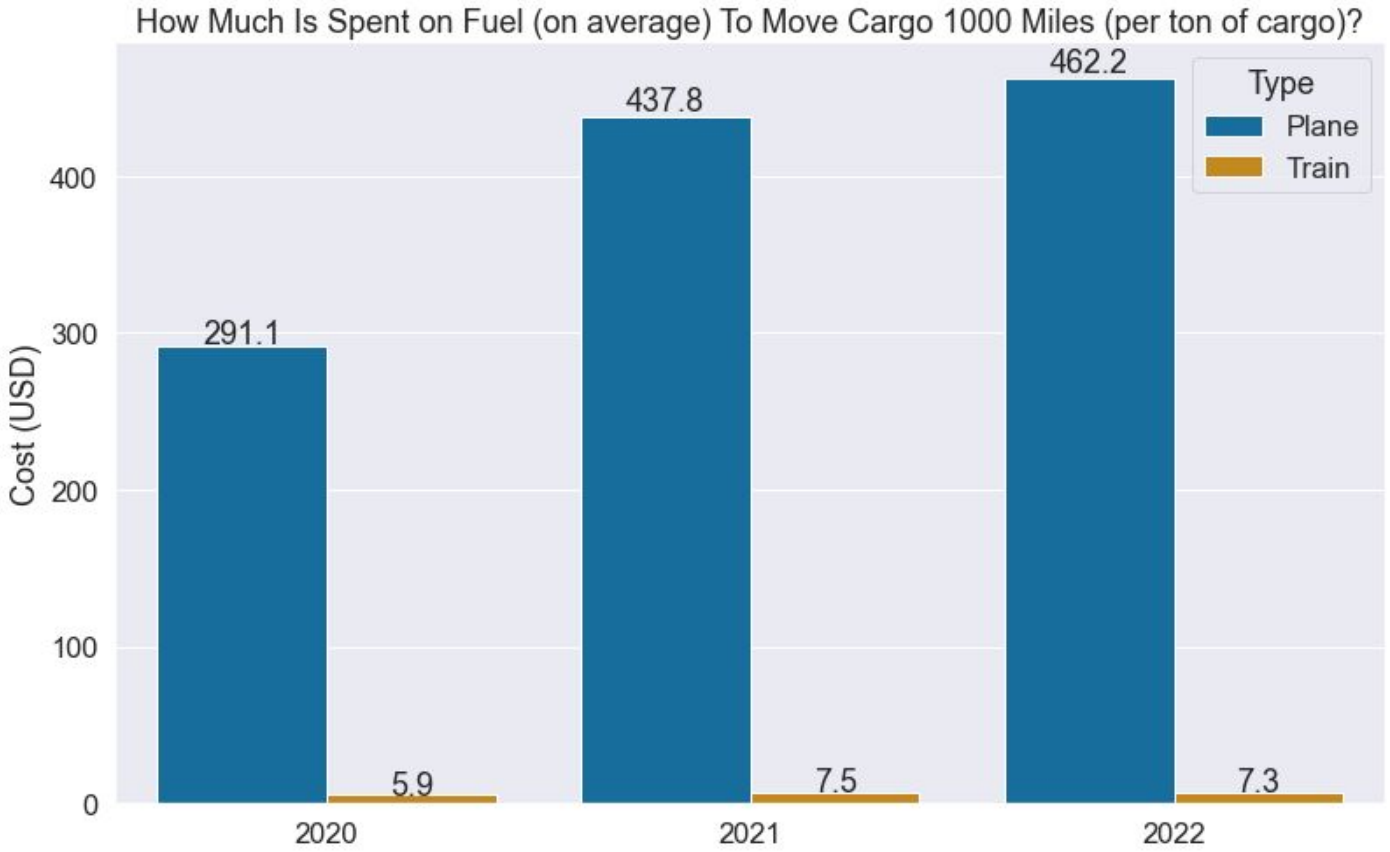
By Plane or Train



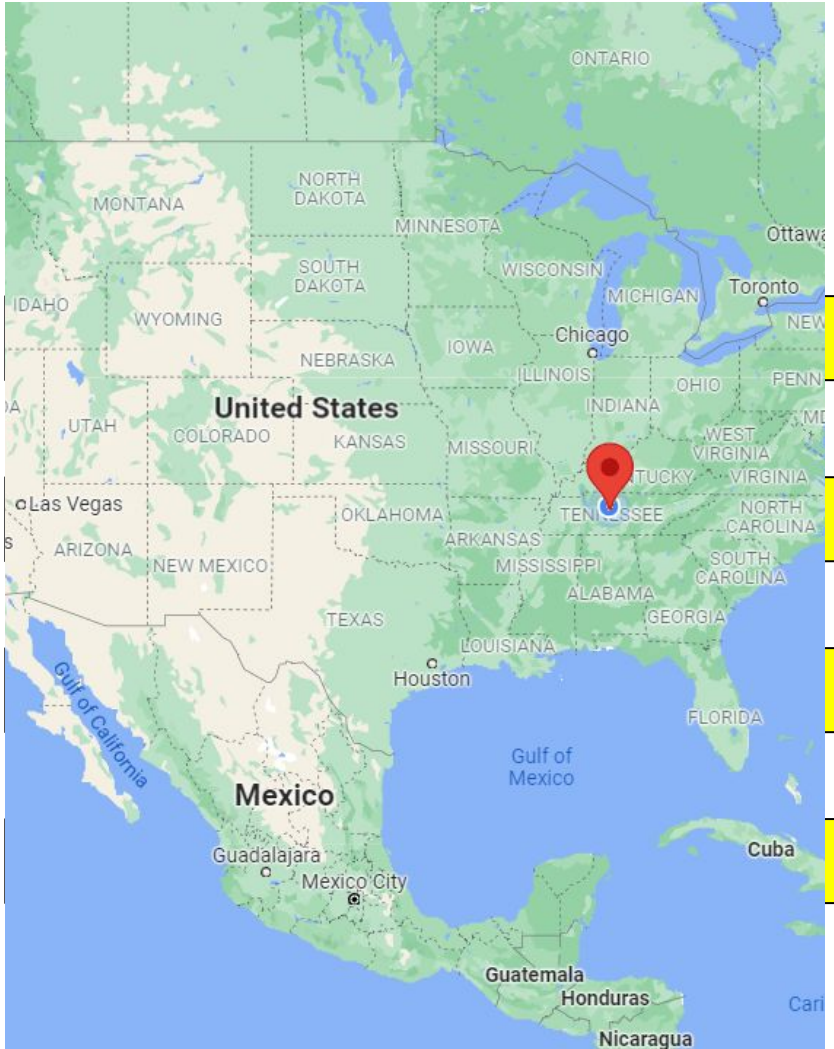
What's the overall impact (1-Ton/1000 miles)?

	Fast Ship	Slow Ship	Small Truck	Medium Truck	Big Truck	Plane	Train
Time (Hours)	38.5	45.5	17.9	17.9	17.9	2	40
Gallons of Fuel	.99	.63	11	6.7	7	222.2	2.3
CO_2 (lbs)	25.37	16.18	247.5	150.7	157.3	4777.8	51.5
Fuel cost 2021	1.80	1.15	36.14	22.00	22.97	437.78	7.52

Is this really the best option?

	Fast Ship	Slow Ship	Train
Time (Hours)	38.5	45.5	40
Gallons of Fuel	.99	.63	2.3
CO_2 (lbs)	25.37	16.18	51.5
Fuel cost 2021	1.80	1.15	7.52

Is this really the best option?



Transporting food by Ship or Train

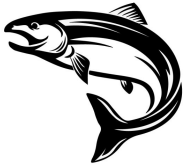
Pros:

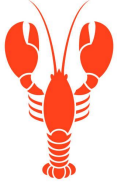
- Fuel efficient over long distances
- Less CO_2 production - by cargo weight
- Effective at moving large amounts at once

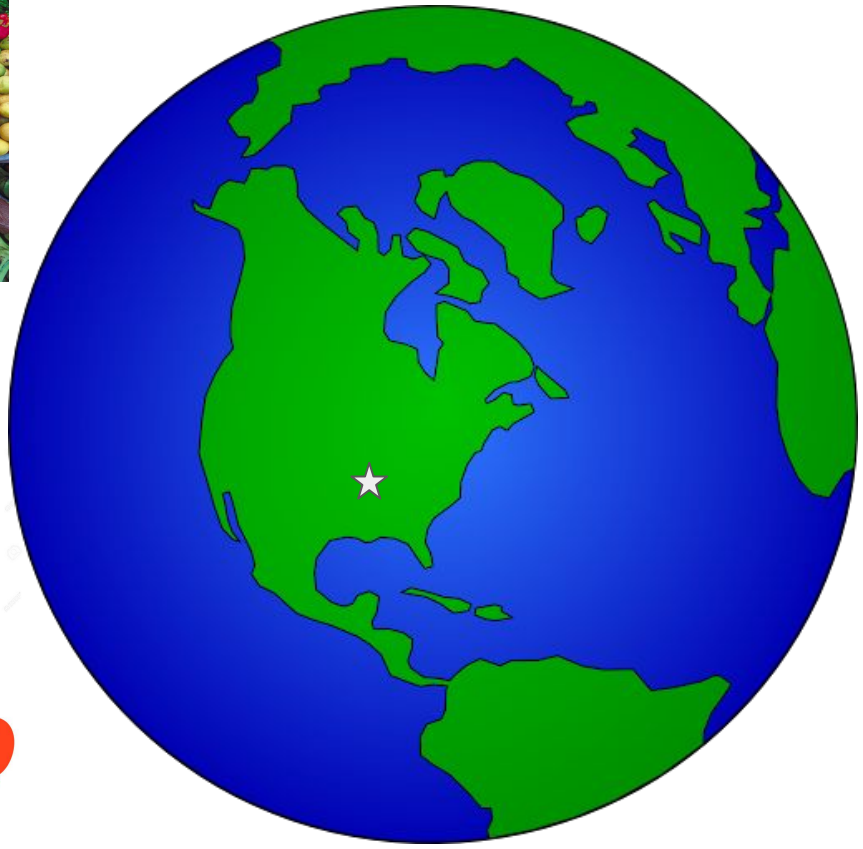
Cons:

- Slow
- Ship and Train is not the end point of that cargo's journey
- Food most likely processed or under-ripe: less nutritious *unless frozen

Globalization







Areas for Further Analysis

- Refine the data for transit by truck by including data for urban driving conditions
- Are shipping companies actually saving fuel and money by traveling slower
  - Started the practice during the 2008 Recession
  - Individual ships save on fuel, but do companies?
  - Does slower ships = less profit? Larger fleets?
- It would be fascinating to further examine where exactly different ingredients are grown and how exactly they're transported, to get a clearer vision of a food-product's journey from origin to market
  - Shipping ports mapped
  - Rail lines mapped
  - Distribution centers highlighted

Questions

?