BUREAU OF TRANSPORTATION STATISTICS (BTS)
TRANSBORDER FREIGHT ANALYSIS DOCUMENTATION

A. ANALYSIS QUESTIONS

1. What are the most commonly used transport modes over time (truck, rail, air, etc.)?
2. How has the freight value trended across Canada and Mexico since 2020?
3. Which commodities contribute the most to freight value and weight?
4. Which ports or regions handle the most freight traffic?
5. How do freight trends vary across seasons or years?
6. Are containerized shipments more valuable than non-containerized ones?
7. How do freight charges vary across transport modes, and what is their impact on total trade value?

B. DATA PREPARATION

Before Preparation

- Over 35M records with 15 parameters
- Millions of null values in Month, Commodity Code, Mexico State, Canada Province, USA State, District/Port, and Domestic/Foreign Columns

Null Values

1. Year – Filled the Null Values in year field with the most previous year, because it was just 1.
2. Month – Grouped by year and filled the empty fields with the mode for the particular year. If mode is unidentified, it is filled with the first month of the year (January)
3. Commodity2 – Group by country and fill with modal commodity code for each country. If modal commodity code is undetermined, fill with a new code category 00, representing Unknown.
4. Both Mexico State and Canada Province cannot be null for any particular row. During dataset loading stage, such rows were excluded.
5. USA State should not be null as well. Execution of the previous code took care of all missing values in this column.
6. Replaced null values in DEPE column with mode grouped by USASTATE.
7. Replaced null values in DF column with inferences from TRDTYPE column. TRDTYPE 1 (Export) means Domestic Mechandise and TRDTYPE 2 (Import) means Foreign Mechandise

Datatype Conversion

8. Changed 'TRDTYPE', 'DISAGMOT', 'COUNTRY', and 'COMMODITY2' datatypes from numeric to category, since they were not going to be used in any form of aggregation.

9. Changed the year and month columns from float to int, and then combined them and changed it to datetime format.
10. In the CONTCODE column (X & 0), some values were represented as 1 in both INT and String datatype, and 0 also as both INT and String. Replaced X and 1 with Containerized and 0 with Non-Containerized for visualization clarity.

Dataset After Preparation

- About 28M records with 15 parameters left (20% records removed)
- About 18M nulls in Mexico State, and about 9M nulls in Canada Province State

C. ANALYSIS, VISUALIZATIONS & INSIGHTS

1. Most Common Transport Modes Over Time


Freight Value by Transport Mode Over Time
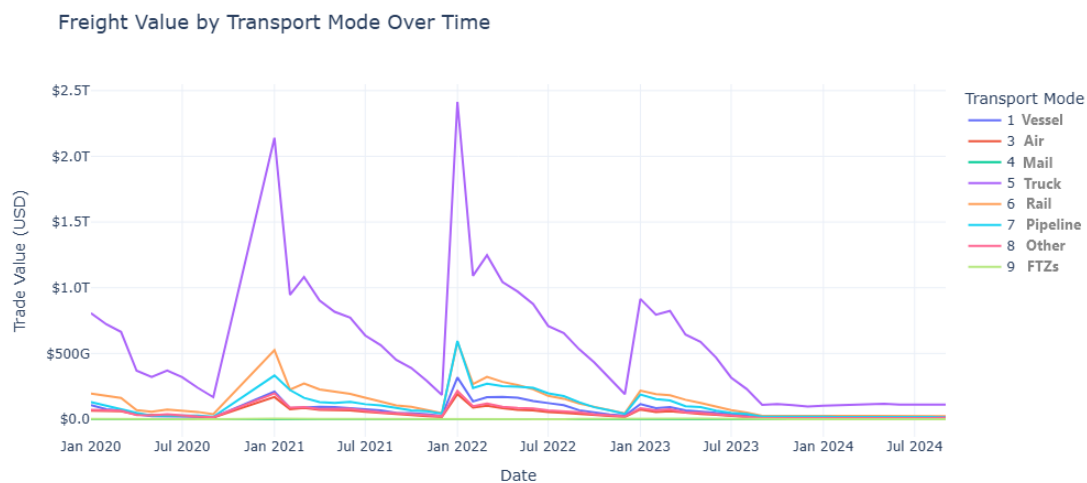
- Truck (5) consistently carries the highest freight value, with sharp peaks around early 2021 and 2022.
- Pipeline (7)—while not the highest in value, shows a steady and persistent pattern.
- Rail (6) follows a similar but slightly lower trend, likely handling bulk commodities over longer distances. Meanwhile, modes like Air and Mail remain low and stable throughout, indicating more niche or lower-volume use.
- Another key trend is the repeated spike in total freight value at the start of 2021 and again in 2022. These could point to seasonal trade patterns or rebounds following disruptions like the COVID-19 pandemic.
- But after early 2022, there's a noticeable dip in trade value across all modes. This may signal market normalization, changes in fuel prices, or broader economic slowdowns.

Key Takeaway

- Trade values consistently peak in the first quarter each year, reflecting seasonal demand cycles.
- Overall, the data reinforces that trucks are the backbone of transborder freight, handling the bulk of trade value consistently over time."

2. Trade Trends Across Canada and Mexico (Exports)


Freight Export Value Trend (Canada vs Mexico)
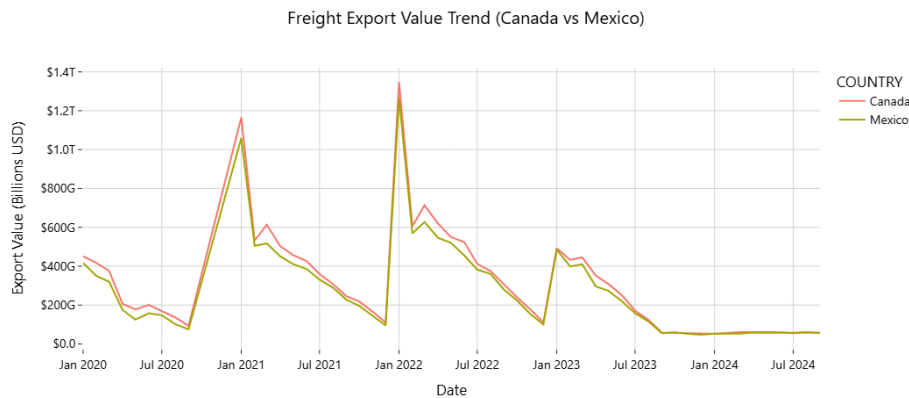
- Both Canada and Mexico show strong export spikes around Jan 2021 and Jan 2022; Presumably due to End-of-year shipments, Contract closures and Seasonal demands
- Canada's export value is consistently higher than Mexico's in most months. However, Mexico closely trails, especially during the spikes in 2022.
- After Jan 2022, there's a gradual decline in exports for both countries; Like due to Economic hardships, Global logistics disruptions, or Policy changes leading to decreased demand
- The trends for both countries are closely aligned, suggesting fairly equal export trade patterns. This could result from common factors like, tariff increments, inflation or increase in oil prices, as has been a trend during those years.

Key Takeaway

- Freight export values peaked sharply in early 2021 and 2022, driven by year-end trade surges.
- Canada consistently led Mexico in export value, though both followed a similar seasonal pattern.
- A gradual decline post-2022 suggests tightening global trade conditions or shifting demand trends.

Trade Trends Across Canada and Mexico (Imports)

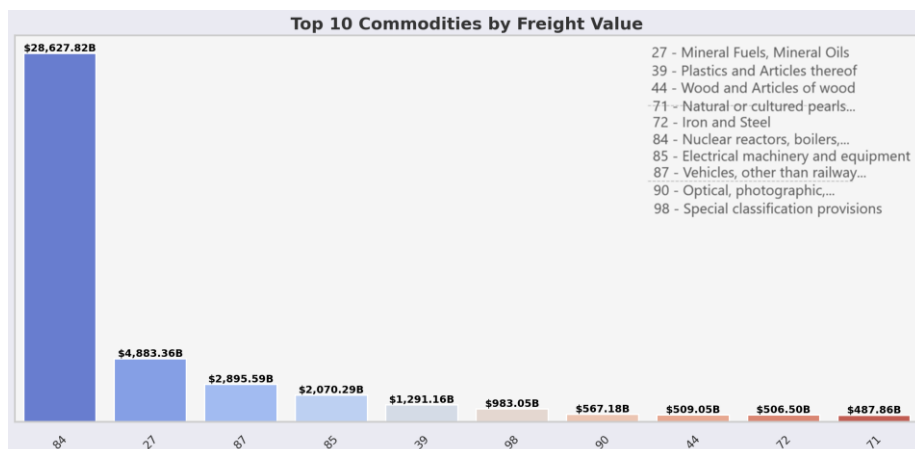Freight Import Value Trend (Canada vs Mexico)
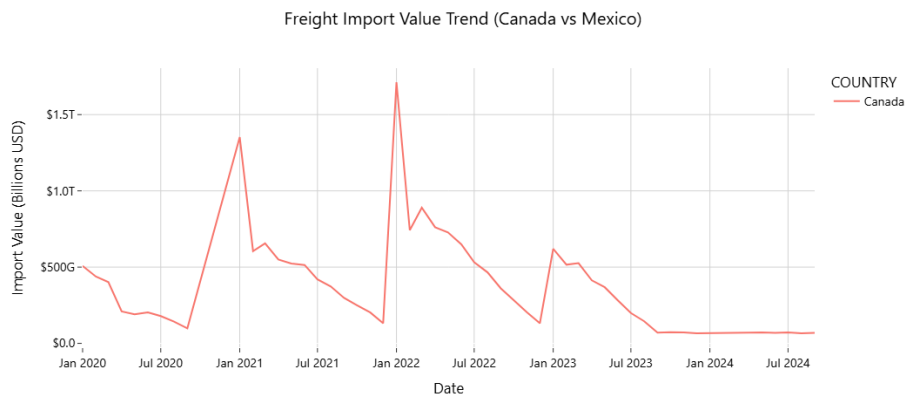
- The import value trend for Canada displays a distinct seasonal pattern, with sharp spikes at the beginning of 2021 and 2022. These peaks likely represent post-holiday restocking or year-start trade realignments, possibly in response to disrupted supply chains from the prior year.

- There is no visible data for Mexico, indicating either data unavailability, import gaps, or a reporting issue.

- From mid-2022 onwards, there is a steady decline in import values, presumably suggesting Reduced demand, Tighter trade policies, Economic corrections post-COVID or Possibly a shift in reliance on domestic alternatives.

Key Takeaway

- Unusual for Mexico to have no import record, maybe a reporting issue.

- Despite seasonal surges, the overall trend for Canada imports is downward, possibly aligning with global signals of slowed trade activity, inflation pressures, and evolving supply chain strategies.

3. Commodities with the most freight value

Top 10 Commodities by Freight Value

27 - Mineral Fuels, Mineral Oils
39 - Plastics and Articles thereof
44 - Wood and Articles of wood
71 - Natural or cultured pearls…
72 - Iron and Steel
84 - Nuclear reactors, boilers,…
85 - Electrical machinery and equipment
87 - Vehicles, other than railway…
90 - Optical, photographic,…
98 - Special classification provisions

$28,627.82B
$4,883.36B
$2,895.59B
$2,070.29B
$1,291.16B
$983.05B
$567.18B
$509.05B
$506.50B
$487.86B

- Commodity 84 (Nuclear Reactors, Boilers, Machinery etc.) is by far the most valuable commodity, with a staggering $28,627.8 billion in total freight value. This indicates its strategic economic significance in trade. The high value may as well be due to how expensive it is.
- Commodity 27 (Mineral Fuels and Oils, etc) follows at $4,883.4 billion, demonstrating the heavy reliance on fossil fuel trade across borders.
- Optical Instruments (90), Wood (44), Iron and Steel (72), and Precious Metals (71) all range between $487.90 billion to $567.20 billion – Lower-tier but still substantial.

Key Takeaway

- Value-heavy commodities tend to be high-tech, industrial, or resource-intensive. This depicts a focus on manufacturing, energy, and advanced equipment in cross-border trade.
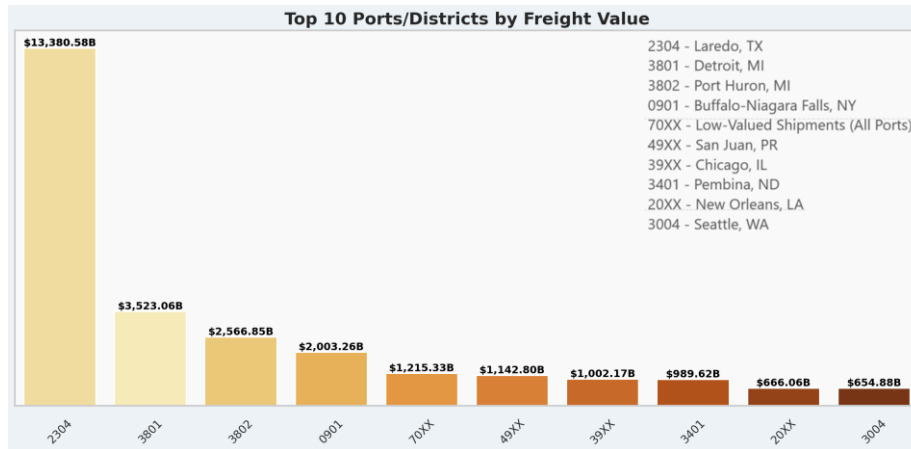
Commodities with the most freight weight
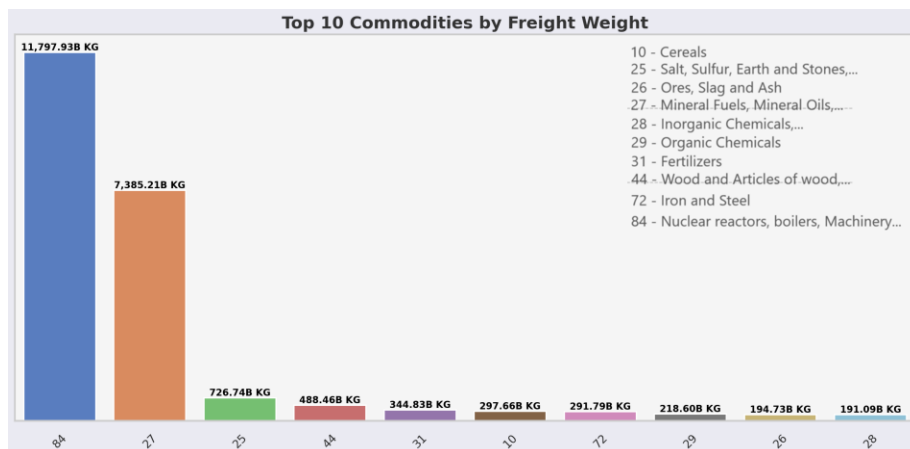
- Commodity 84 (Machinery…) again tops the chart, with 11,797.9 billion kg, indicating not just high value but massive volume, underscoring its dominant logistical footprint.
- Commodity 27: Mineral Fuels and Oils follows with 7,385.2 billion kg, emphasizing its dual importance in value and volume.
- The other major commodities fell below 800 billion kg:

Key Takeaway

- High-weight commodities tend to be raw materials or bulk industrial goods, reflecting the importance of heavy industries, construction, and agriculture.

4. Top 10 Ports by Freight Value

Top 10 Ports/Districts by Freight Value

2304 - Laredo, TX
3801 - Detroit, MI
3802 - Port Huron, MI
0901 - Buffalo-Niagara Falls, NY
70XX - Low-Valued Shipments (All Ports)
49XX - San Juan, PR
39XX - Chicago, IL
3401 - Pembina, ND
20XX - New Orleans, LA
3004 - Seattle, WA

- Port 2304 (Laredo, TX) remains the undisputed leader with $13,380.6B, handling nearly four times the value of its nearest competitor.
- Detroit, MI (3801) and Port Huron, MI (3802) continue to rank high with $3,523.1B and $2,566.8B, respectively, reflecting strong U.S.–Canada automotive and manufacturing trade.
- Buffalo-Niagara (0901) and Chicago (39XX) also make the list, showing the importance of northern industrial corridors.
- San Juan, PR (49XX) and low-value aggregated codes (70XX) appear, indicating high volume trade hubs outside the mainland.
- Notably, Port 3004 (Seattle, WA) appears in the 10th spot now, highlighting the West Coast's contribution to high-value freight.

Key Takeaway
- Laredo, TX (Port 2304) dominates freight value, handling $13.4T—nearly four times any other port.
- Detroit and Port Huron follow, reflecting intense high-value trade along the U.S.–Canada corridor.

Top 10 Ports by Freight Weight
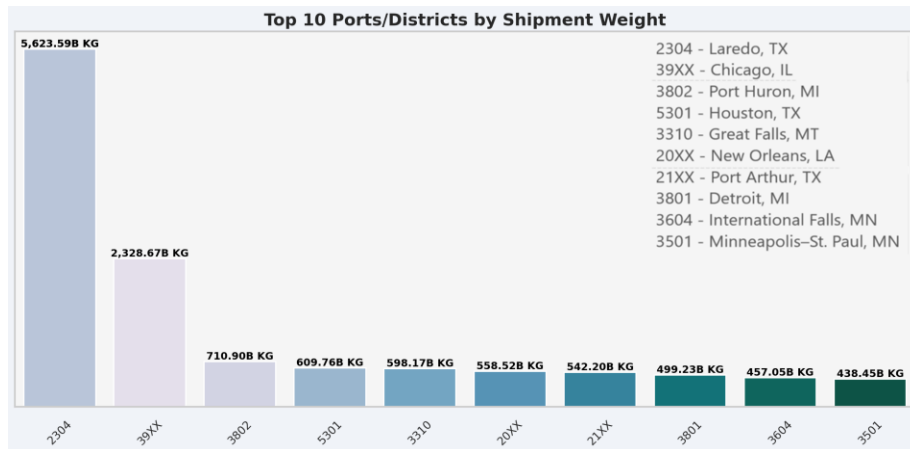
- Port 2304 (Laredo, TX) again leads with 5,623.6B kg, showing its unmatched dominance in both freight volume and value.

- Chicago (39XX) is the second-highest in weight (2,328.7B kg), meaning it is also able to handle large volumes of lower-value or bulk goods.

- Detroit (3801), Seattle (3004), and Minneapolis (3501) also appear, indicating inland and Gulf-linked transport corridors.

Key Takeaway

- Laredo is the top freight hub by weight too (5.6T kg), highlighting massive trade flows with Mexico.

- Chicago, Houston, and Great Falls manage heavy bulk goods, supporting inland and Gulf logistics.

5. Yearly Freight Trend by Total Value
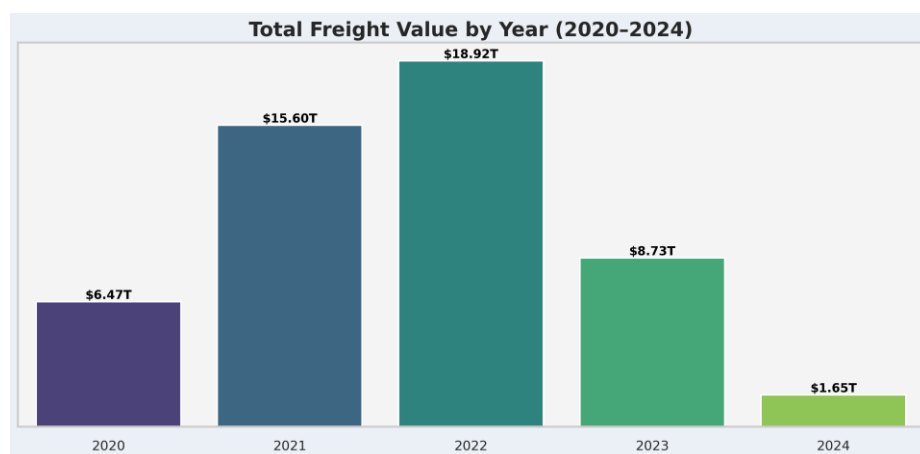
- 2022 recorded the highest freight value, totaling approximately $18.9 trillion, likely driven by post-pandemic economic recovery and increased trade volumes.

- There was a sharp dip in 2020, with total value around $6.5 trillion, reflecting the impact of global disruptions due to COVID-19.

- Freight value declined significantly from 2023 to 2024, with 2024 dropping to only $1.65 trillion, possibly due to reduced trade activities, stricter policies, or incomplete data.
- The trend shows a boom between 2020 and 2022, followed by a downward trajectory starting in 2023.

Key Takeaway

- Freight value peaked in 2022 following a post-pandemic surge but declined steeply by 2024.
- Trade volume appears to mirror broader economic cycles.
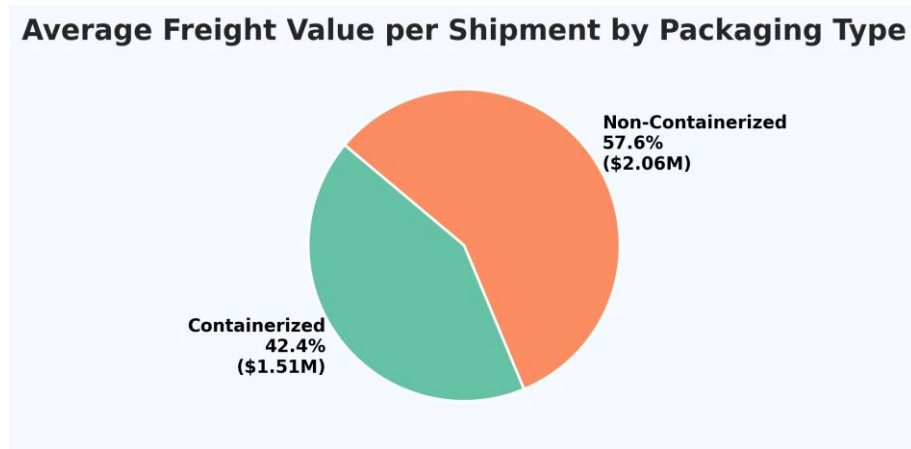
Monthly Freight Trend by Total Value

Average Freight Value by Month (2020-2024)
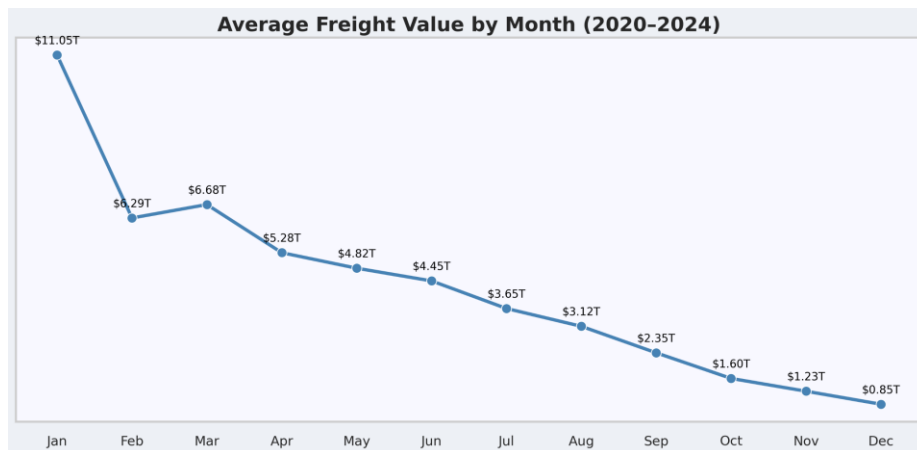
- January dominates with the highest average trade value (~$11T), suggesting strong start-of-year shipping or fiscal-related activities.
- A steady month-on-month decline is evident, with December recording the lowest average (~$0.85T).
- Peaks in March and occasional plateaus suggest mid-quarter bursts before value dips again.
- The data labels make it clear that Q1 drives most of the annual trade performance.

Key Takeaway

- Freight activity is highest in January, tapering off toward year-end.
- Seasonal pattern highlights the first quarter as the most commercially active.

6. Yearly Freight Trend by Total Value

Average Freight Value per Shipment by Packaging Type

Non-Containerized
57.6%
($2.06M)

Containerized
42.4%
($1.51M)

- Non-containerized shipments have a higher average freight value per shipment ($2.06M) compared to containerized ones ($1.51M), accounting for 57.6% of total value.
- This suggests that high-value or specialized goods may more often be transported without containers, possibly due to size, handling, or mode-specific constraints.

7. Freight Charges and Freight Value Correlation

Freight Charges vs. Trade Value by Transport Mode

Transport Mode
1
3
4
5
6
7
8
9

Trade Value (USD)

Freight Charges (USD)
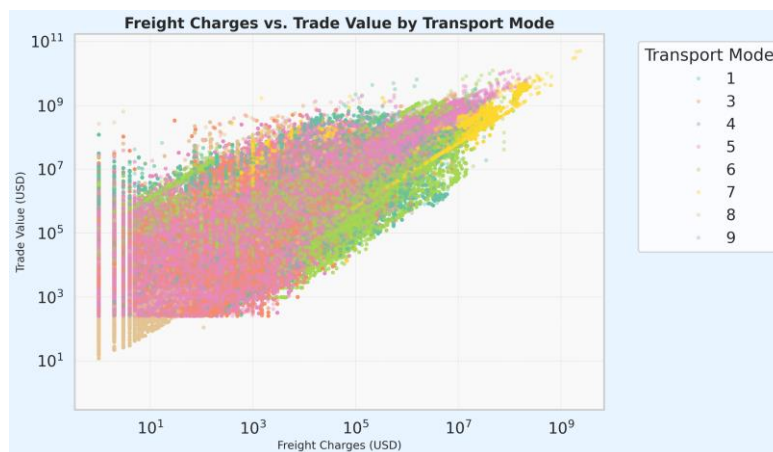
- Across all transport modes, there's a clear upward trend; As expected, as trade value increase, so does the freight charges. Higher-value goods often incur higher freight costs, either due to weight, insurance, speed, or special handling.
- A few extreme points exist in the top-right corner (high trade value and high cost), possibly representing oversized or high-risk cargo, urgent air shipments, or specialized equipment.

Identifying outliers in Freight Charges

Distribution of Freight Charges by Transport Mode
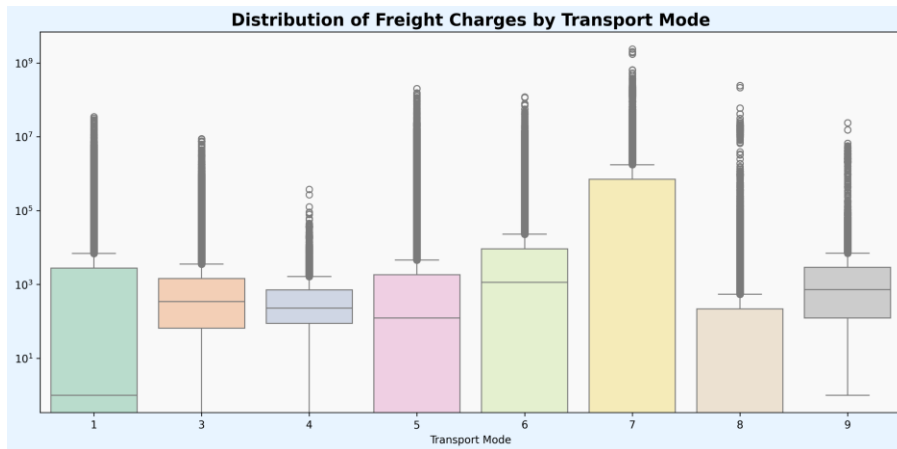
- Transport Mode 7 (Pipeline) shows the highest median and variability in freight charges. It includes many high-value outliers, suggesting specialized freight transport cases.
- All modes show a significant number of outliers, especially Modes 6, 7, and 9, indicating that exceptional freight circumstances (e.g., emergencies, premium cargo) can sharply increase charges.
- The use of a log scale reveals exponential variations across modes, stressing the importance of mode selection in cost planning.

Key Takeaway

- Freight charges and trade value show a strong positive relationship across all transport modes.
- Freight charges vary significantly by transport mode, with Mode 7 (Pipelines) being the most expensive and volatile.

D. **GENERAL INSIGHTS & CONCLUSIONS**

1. **Dominance of Truck Transport**: Truck transport (Mode 5) consistently emerged as the dominant freight mode by value and volume across years. This underscores its critical role in North American trade, especially for cross-border short-haul and just-in-time delivery.

2. **Seasonality in Trade Trends**: There are strong seasonal patterns in both exports and imports. Peaks in January and March (Q1) likely reflect fiscal year starts, contract renewals, or inventory restocking periods. However, there's a sharp and steady decline post-2022.

3. **Canada's Trade Lead**: Canada leads Mexico in export value throughout the analysis period, though both follow similar seasonal spikes. Import data for Mexico is missing or misreported, creating an information gap.

4. **Commodity Concentration**: A handful of commodities drive most of the trade value—especially Machinery (Commodity 84), and Fuel/Oils (Commodity 27). These sectors are strategic to industrial and energy economies and dominate both weight and value.

5. **Port Significance**: Laredo, TX (Port 2304), handles the highest volume and value, cementing its role as the primary transborder hub. Detroit, Chicago, and Seattle also serve as major conduits for goods.

6. **Freight Charges and Mode Volatility**: Freight charges increase with trade value, and modes like Pipelines (7) and Rail (6) exhibit high cost variability. Pipelines in particular show high medians and extreme outliers—suggesting specialized and high-cost use cases.

7. **Containerization Observations**: Non-containerized shipments, though fewer, carry higher average freight value than containerized ones—possibly due to bulk commodities, large machinery, or specialized shipments.

8. **Outlier Behaviour**: Outliers in freight charges are associated with high-value goods and specialized handling (e.g., pipelines, air cargo, oversized equipment). These significantly skew averages and require tailored strategies in analysis and budgeting.

E. RECOMMENDATIONS

1. **Improve Data Quality for Mexico Imports**: There's a significant data gap for Mexican imports. Stakeholders should advocate for improved bilateral reporting to fill analytical gaps and inform better policy.

2. **Prioritize Infrastructure Investment in Top Ports**: Laredo, Detroit, and Chicago are core trade arteries. Investment in automation, digitization, and decongestion in these areas can yield large-scale efficiency.

3. **Diversify and Optimize Freight Modes**: Given cost volatility in Pipelines, businesses should optimize freight mode selections based on cargo type, value, and urgency, supported by predictive cost modeling.

4. **Seasonal Planning is Crucial**: Businesses should align production, logistics, and customs capacity with Q1 demand surges to avoid bottlenecks and freight inflation.

5. **Outlier Mitigation Strategies**: Develop outlier (extreme values) handling protocols in pricing models to avoid distortion. Special cargo should have dedicated budgeting and logistics pipelines.

6. **Support Bulk and Specialized Freight Innovations**: For high-value, non-containerized cargo, explore new packaging, tracking, and transport methods that maintain value while reducing risk and cost.

Githib link for full project: https://github.com/dspselorm/transborder-freight-analysis