# Analysis of Maritime Costs, Delays and Tariff Impacts

Blair Jones
CU Boulder
December 2025

# AGENDA

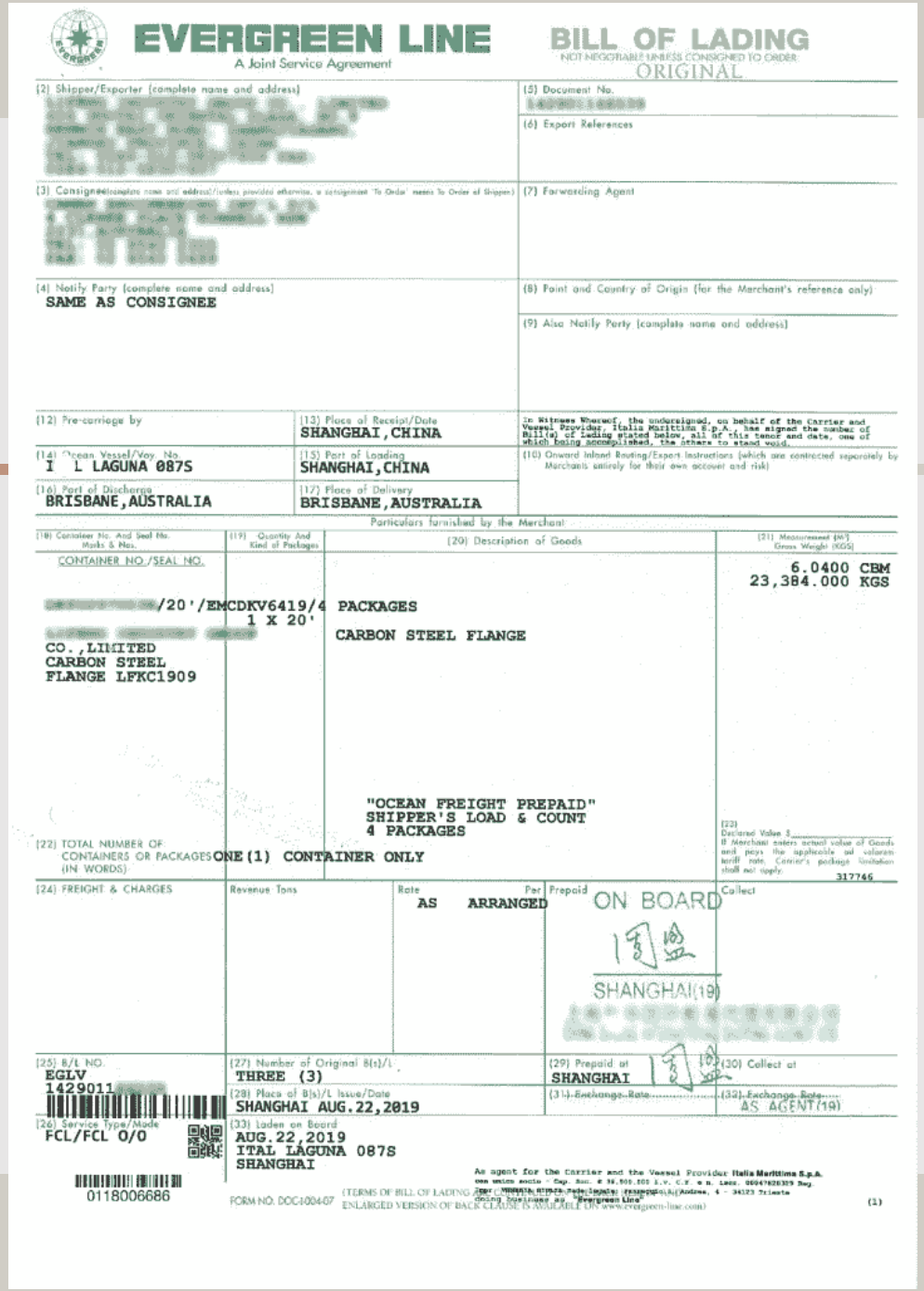
Data

Predictions – Delays & Costs

Tariff Impacts

# Data

- International shipments backed by bill of lading (BOL)
- Maintained by US Customs, considered public record
- Services like importyeti.com maintain a database of bills of lading, available to access (for a fee)
- Downloads in tabular form, .csv



EVERGREEN LINE
A Joint Service Agreement

BILL OF LADING
NOT NEGOTIABLE UNLESS CONSIGNED TO ORDER
ORIGINAL

(2) Shipper/Exporter (complete name and address)
[redacted]

(5) Document No.
[redacted]

(6) Export References

(3) Consignee (complete name and address) (unless provided otherwise, a consignment "To Order" means To Order of Shipper)
[redacted]

(7) Forwarding Agent

(4) Notify Party (complete name and address)
SAME AS CONSIGNEE

(8) Point and Country of Origin (for the Merchant's reference only)

(9) Also Notify Party (complete name and address)

(12) Pre-carriage by

(13) Place of Receipt/Date
SHANGHAI,CHINA

In Witness Whereof, the undersigned, on behalf of the Carrier and Vessel Provider, Italia Marittima S.p.A., has signed the number of Bill(s) of Lading stated below, all of this tenor and date, one of which being accomplished, the others to stand void.

(14) Ocean Vessel/Voy. No.
I L LAGUNA 087S

(15) Port of Loading
SHANGHAI,CHINA

(10) Onward Inland Routing/Export Instructions (which are contracted separately by Merchants entirely for their own account and risk)

(16) Port of Discharge
BRISBANE,AUSTRALIA

(17) Place of Delivery
BRISBANE,AUSTRALIA

Particulars furnished by the Merchant

| (18) Container No. And Seal No. Marks & Nos. | (19) Quantity And Kind of Packages | (20) Description of Goods | (21) Measurement (M³) Gross Weight (KGS) |
|---|---|---|---|
| CONTAINER NO./SEAL NO. | | | 6.0400 CBM<br>23,384.000 KGS |
| [redacted]/20'/EMCDKV6419/4<br>[redacted]<br>CO.,LIMITED<br>CARBON STEEL<br>FLANGE LFKC1909 | 1 X 20'<br>4 PACKAGES | CARBON STEEL FLANGE | |

"OCEAN FREIGHT PREPAID"
SHIPPER'S LOAD & COUNT
4 PACKAGES

(22) TOTAL NUMBER OF CONTAINERS OR PACKAGES (IN WORDS): ONE (1) CONTAINER ONLY

(23) Declared Value $ ____ If Merchant enters actual value of Goods and pays the applicable ad valorem tariff rate, Carrier's package limitation shall not apply.

317745

| (24) FREIGHT & CHARGES | Revenue Tons | Rate | Per | Prepaid | Collect |
|---|---|---|---|---|---|
| | | AS ARRANGED | | ON BOARD<br>SHANGHAI(19) | |

(25) B/L NO.
EGLV
1429011[redacted]

(27) Number of Original B(s)/L
THREE (3)

(29) Prepaid at
SHANGHAI

(30) Collect at

(28) Place of B(s)/L Issue/Date
SHANGHAI AUG.22,2019

(31) Exchange Rate

(32) Exchange Rate
AS AGENT(19)

(26) Service Type/Mode
FCL/FCL O/O

(33) Laden on Board
AUG.22,2019
ITAL LAGUNA 087S
SHANGHAI

0118006686

As agent for the Carrier and the Vessel Provider Italia Marittima S.p.A.

FORM NO: DOC1004-07 (TERMS OF BILL OF LADING ENLARGED VERSION OF BACK CLAUSE IS AVAILABLE ON www.evergreen-line.com)

(1)

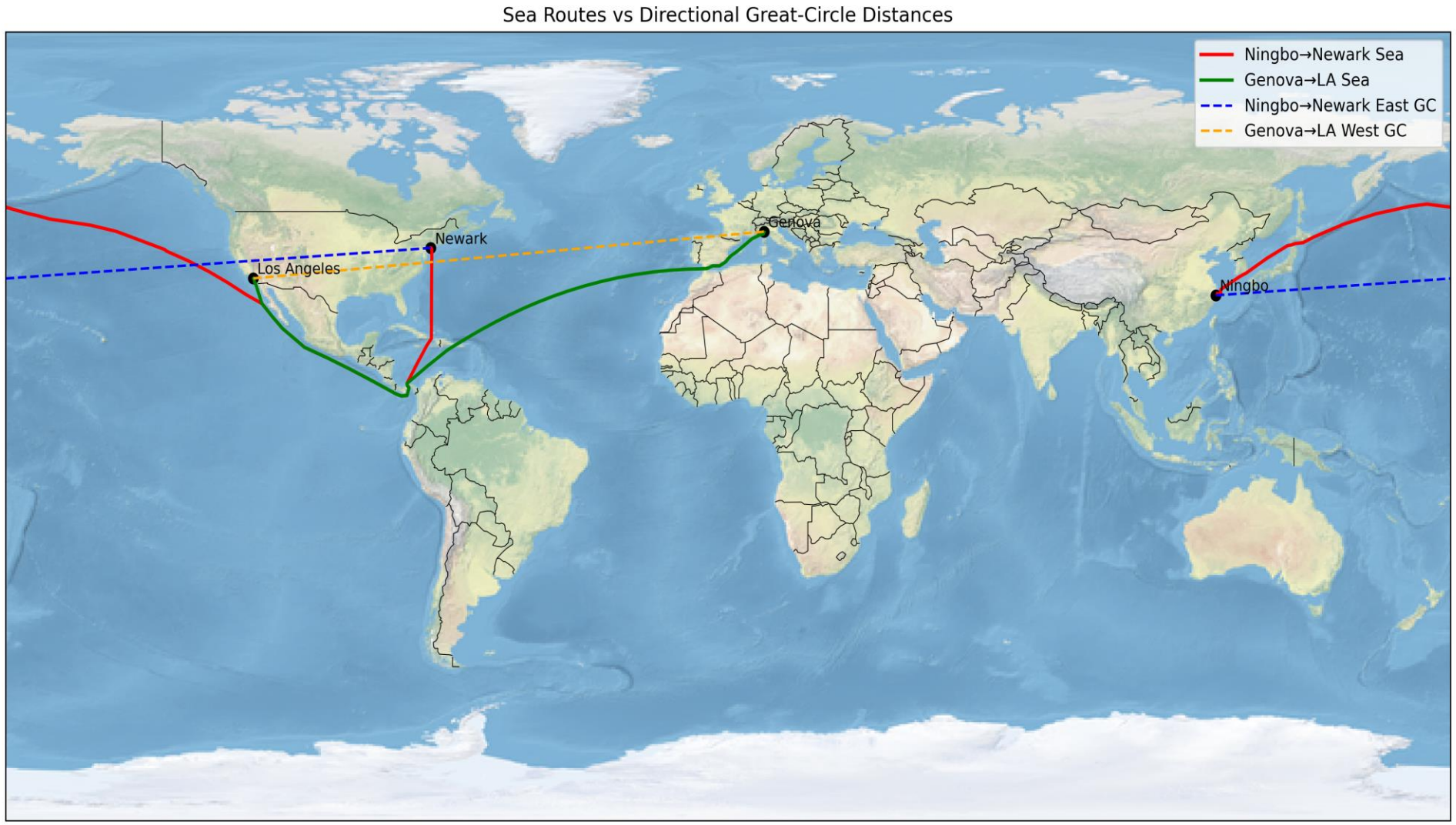
# Features

Haversine distance vs. actual sea route distance

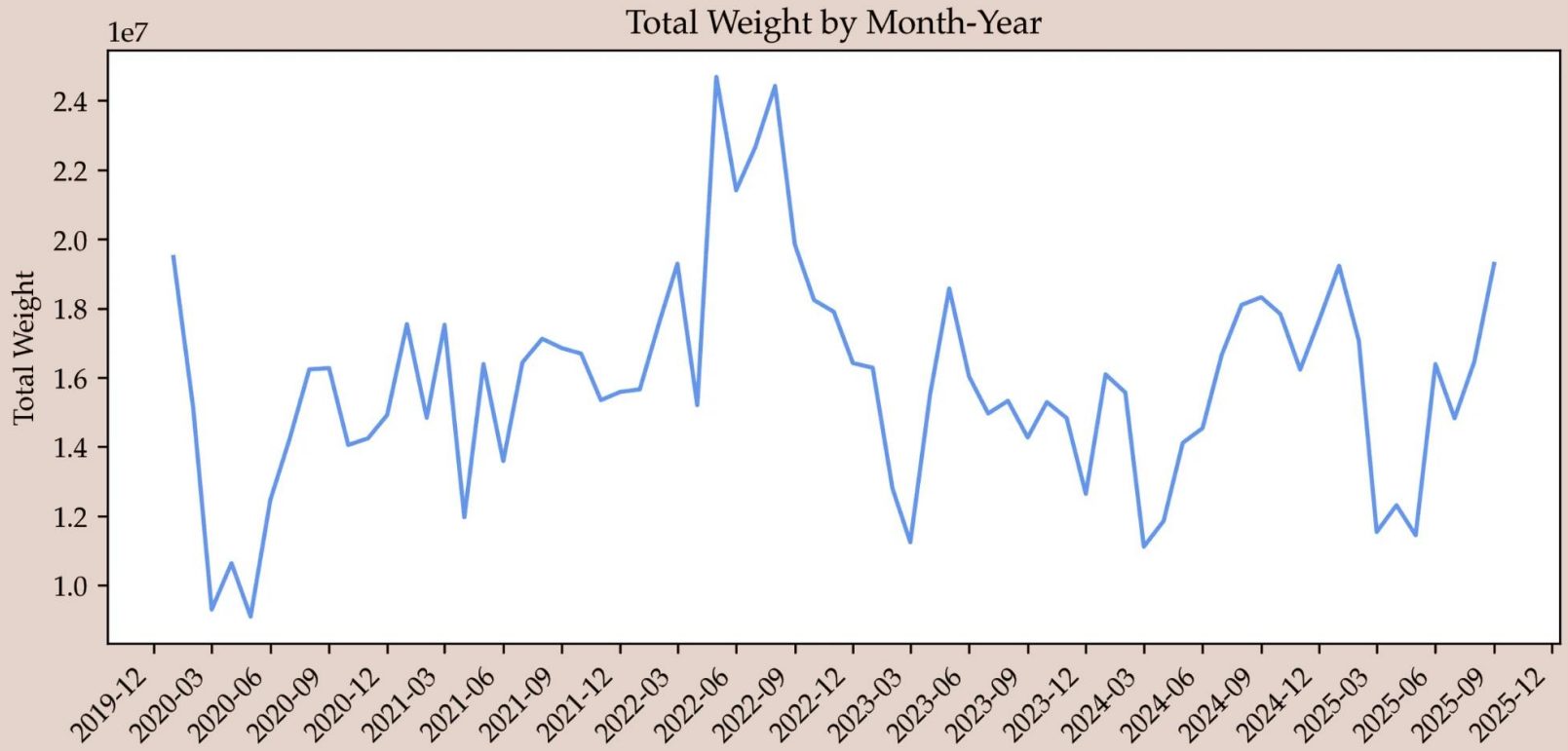
Top customers / suppliers

Route and port frequency

Seasonality



# Shoes Data

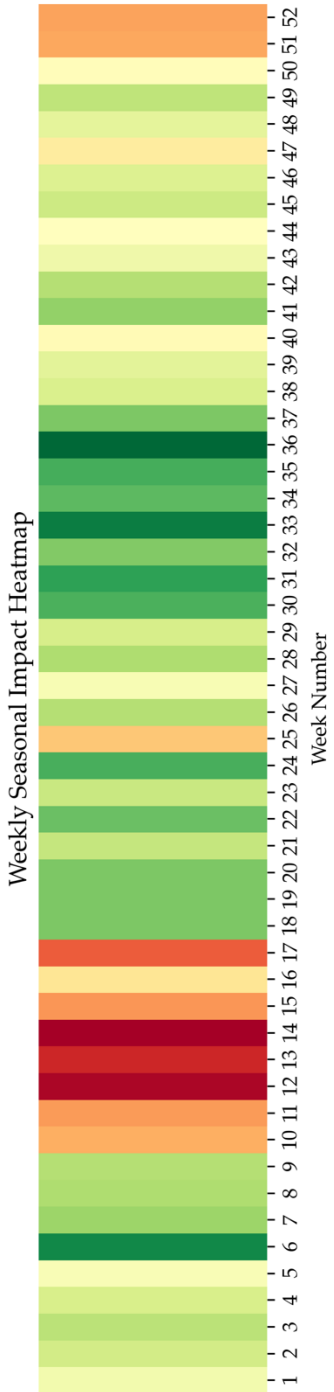



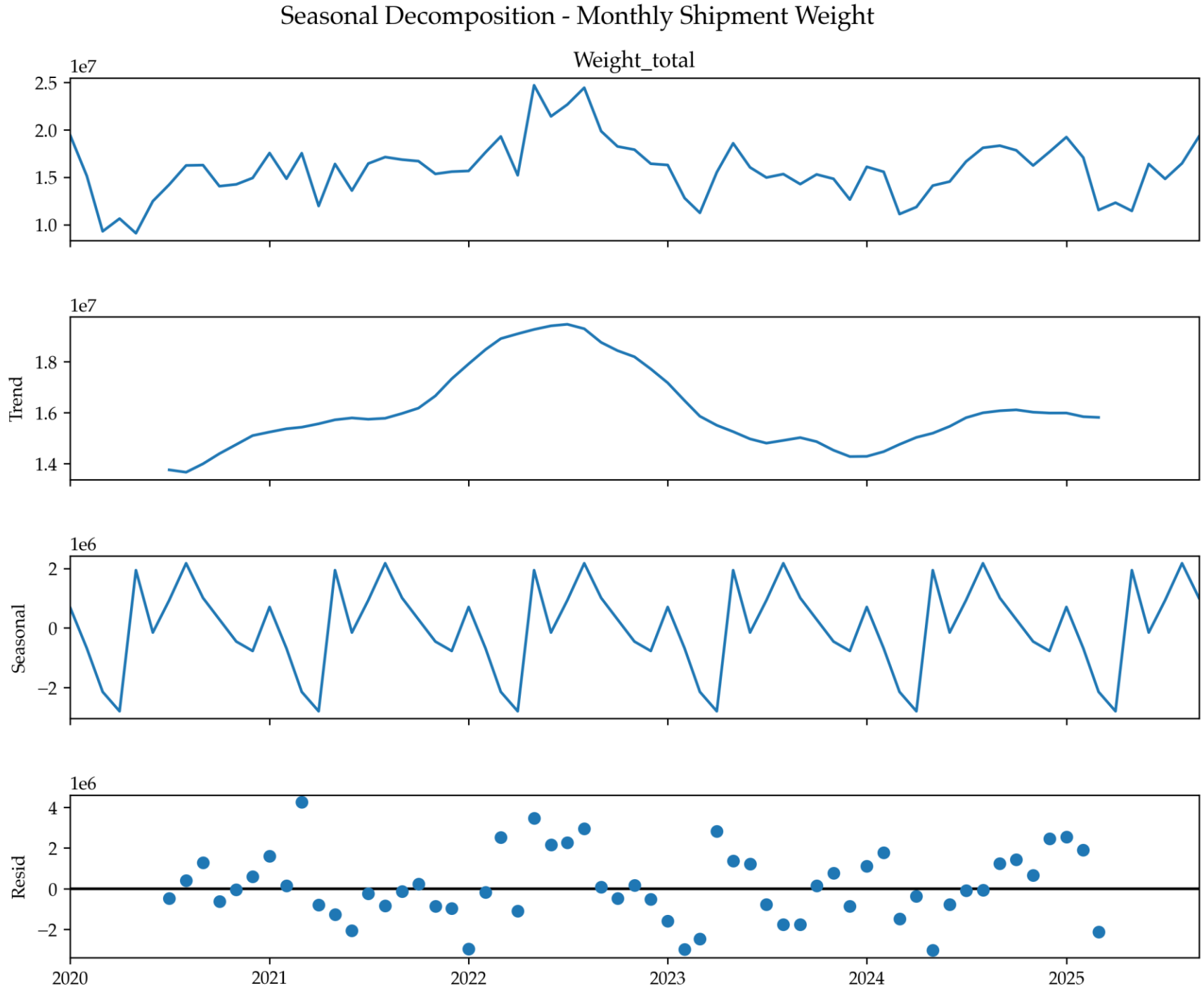

Obtained from product search “shoes” at importyeti.com

5+ years data was obtained

Need to be cautious of semantic mismatches (e.g., brake shoes rather than footwear)

Cleaned shipment data 161,214 lines


Weekly Seasonal Impact Heatmap
Week Number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

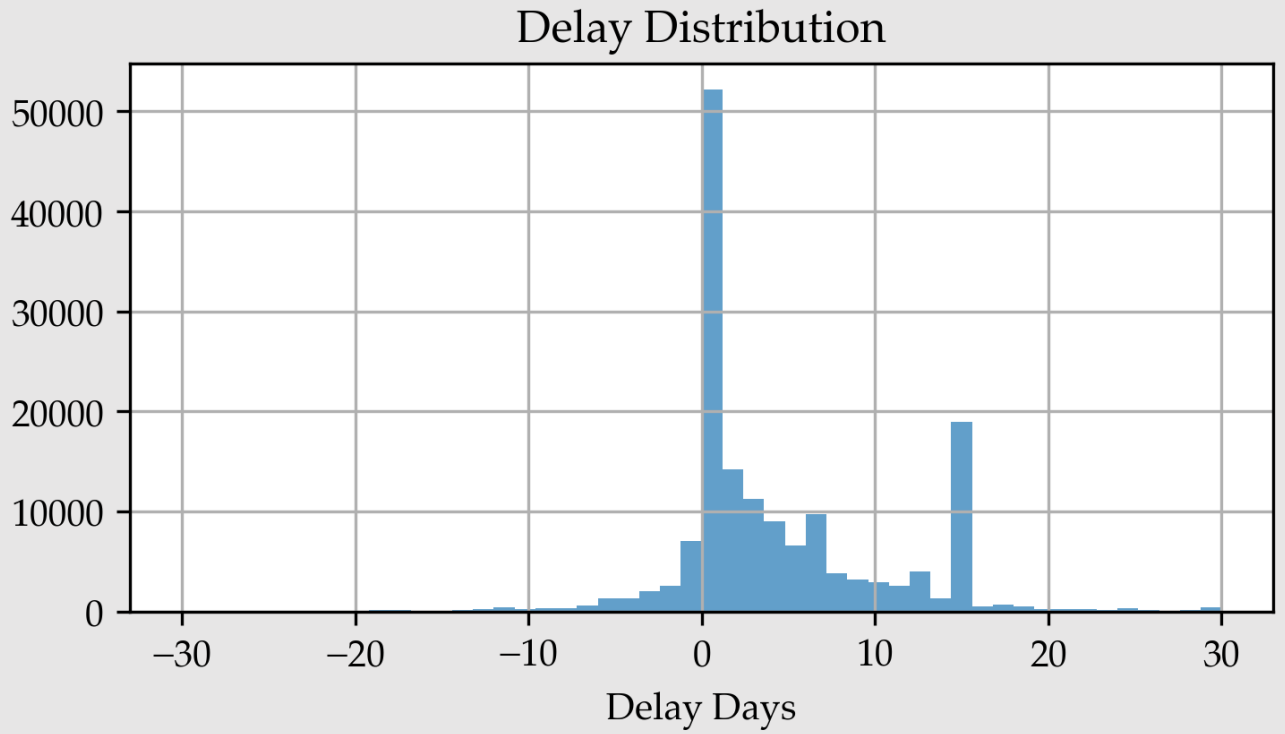

Seasonal Decomposition - Monthly Shipment Weight
Weight_total
1e7
2.5
2.0
1.5
1.0
Trend
1e7
1.8
1.6
1.4
Seasonal
1e6
2
0
−2
Resid
1e6
4
2
0
−2
2020
2021
2022
2023
2024
2025

# Delays

Data has Arrival Date and Estimated Arrival Date

Bi-modal distribution of delay days

2021 saw significant delays in a supply chain “crisis”

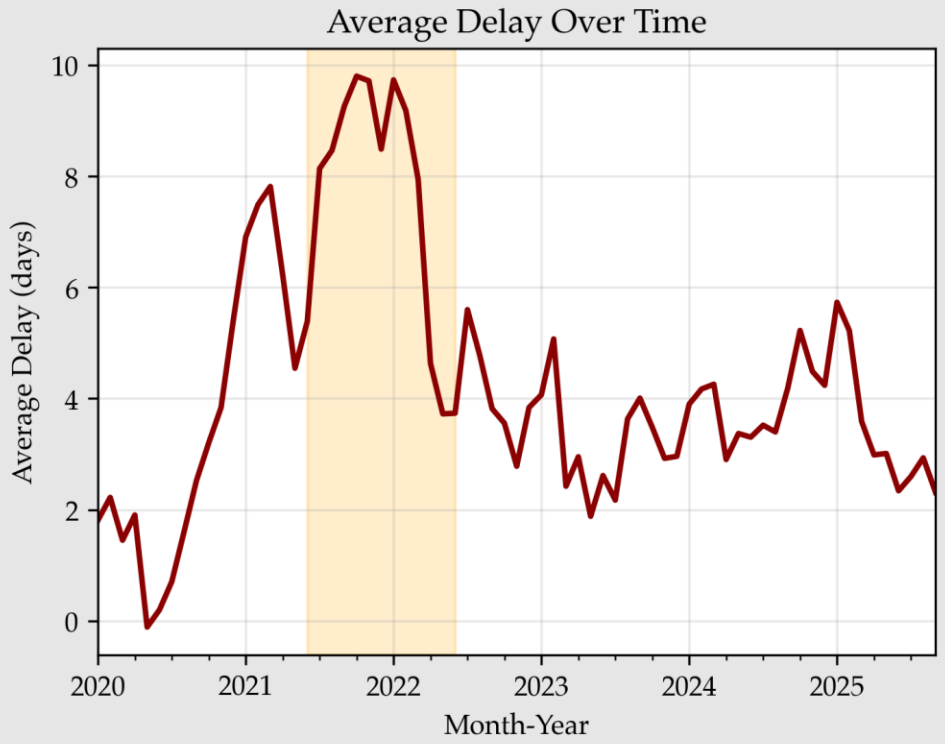


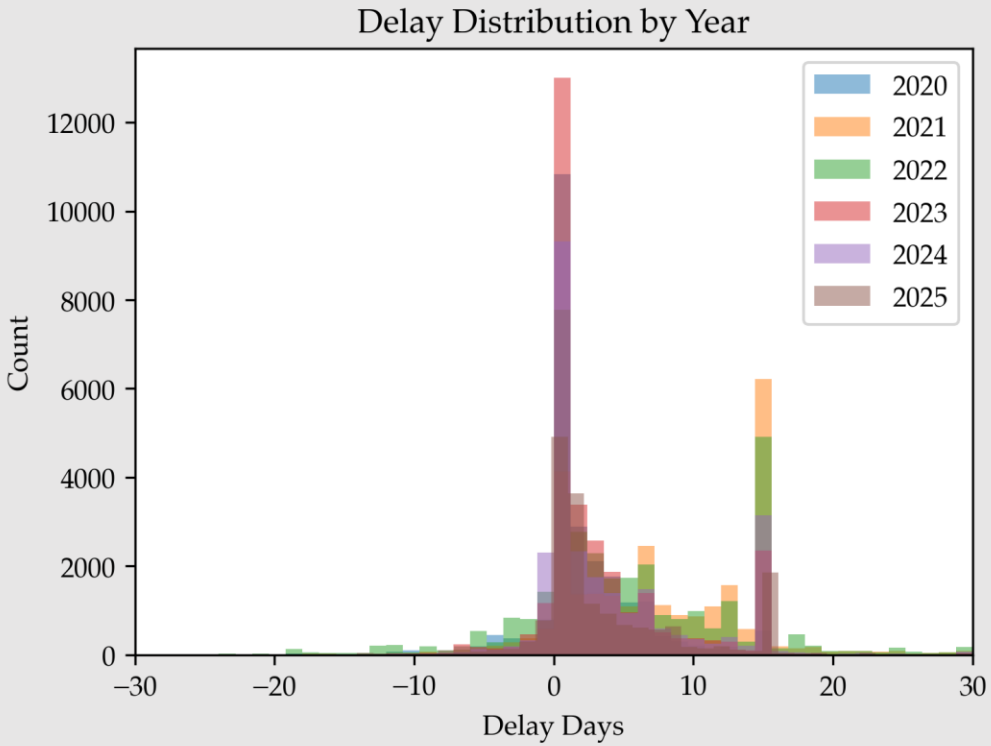

Delay Distribution

| Category | Count (% of Total) |
|---|---|
| Early ($< -1$ days) | 17,102 (10.7%) |
| On Time ($-1$ to 4 days) | 86,578 (54.1%) |
| Slight Delay (4–9 days) | 23,200 (14.5%) |
| Major Delay ($> 9$ days) | 33,243 (20.8%) |

Delays by COVID Period

| Period | Major Delay Rate | Average Delay (days) |
|---|---|---|
| Pre-COVID | 2.7% | 2.0 |
| COVID Peak (Mar–Dec 2020) | 5.4% | 2.1 |
| Post-lockdown 2021 | 42.2% | 7.7 |
| Supply Chain Crisis 2021–22 | 43.4% | 7.6 |
| Recovery (2022+) | 16.2% | 3.6 |




Yearly Summary

| Year | Shipments | Avg Delay | Median | Major Delays | Major % |
|---|---|---|---|---|---|
| 2020 | 24,270 | 2.10 | 1.00 | 1,180 | 4.9% |
| 2021 | 27,055 | 7.71 | 7.00 | 11,408 | 42.2% |
| 2022 | 34,701 | 5.07 | 3.00 | 9,571 | 27.6% |
| 2023 | 30,156 | 3.05 | 1.00 | 3,579 | 11.9% |
| 2024 | 26,257 | 3.94 | 2.00 | 4,730 | 18.0% |
| 2025 | 17,684 | 3.54 | 1.00 | 2,775 | 15.7% |
| **TOTAL** | 160,123 | 4.33 | 2.00 | 33,243 | 20.8% |

**Statistical Test:** 2021 vs other years. The average delay in 2021 was 7.71 days, compared with 3.64 days in other years. A t-test comparing 2021 to the other years yielded a t-statistic of 99.778 with a p-value ≈ 0, indicating that the difference is highly significant.

# Post June-2022 Delay Analysis

## ANOVA: Delay Differences by Carrier - Top 5

- **F-statistic:** 5854.956
- **p-value:** $< 0.0001$
- **Total shipments reviewed:** 28,948

**Result: Significant.** Different carriers have significantly different delay patterns.

### Average Delays by Carrier

| Carrier | Avg. Delay (days) | Count (n) |
|---|---|---|
| MAEU – Maersk Line | 1.36 | 10,399 |
| BANQ – Kuehne & Nagel Inc. | 11.56 | 7,943 |
| MEDU – MSC Mediterranean Shipping Company | 3.19 | 4,292 |
| CMDU – Compagnie Maritime D'Affrètement | 2.81 | 3,423 |
| COSU – China Ocean Steamship Ltd. | 2.83 | 2,891 |

## Seasonal Pattern Detection

- **Kruskal–Wallis H-statistic:** 1577.075
- **p-value:** $< 0.0001$

**Result: Significant.** Delays vary seasonally.

### Average Delay by Month

| Month | Avg. Delay (days) |
|---|---|
| 1 | 4.88 |
| 2 | 5.17 |
| 3 | 4.28 |
| 4 | 3.38 |
| 5 | 2.99 |
| 6 | 2.81 |
| 7 | 3.93 |
| 8 | 4.06 |
| 9 | 3.59 |
| 10 | 4.53 |
| 11 | 3.59 |
| 12 | 3.91 |

# Prediction Models for Delays

Model Performance on Delay Prediction

| Model | RMSE (days) | $R^2$ |
|---|---|---|
| Baseline RF | 3.303 | 0.663 |
| Tuned RF | 3.406 | 0.642 |
| Tuned XGB | 3.712 | 0.575 |

**Notes:** Post June 2022. Delay statistics: mean = 3.60 days, std = 5.69 days.

Feature Importances for Delay Prediction

| Feature | Importance |
|---|---|
| carrier | 0.2285 |
| day_of_year | 0.1616 |
| months_since_start | 0.0770 |
| arr_port_volume | 0.0513 |
| company_freq | 0.0577 |
| quantity_per_teu | 0.0459 |

# Cost Predictions

| Model | RMSE ($) | $R^2$ |
|---|---|---|
| OLS | 11.7511 | 48.14% |
| Random Forest | 6.3425 | 84.89% |
| XGBoost | 5.9535 | 86.69% |
| MLP | 5.9194 | 86.84 % |
| ResNet | 6.1717 | 85.70% |
| Attention | 5.7805 | 87.45% |
| Mean | 24.27 | – |
| Std Dev | 16.47 | – |

About 11% of shipments include a cost field. CIF (Cost, Insurance, Freight) an incoterm which states the supplier is responsible for insuring the goods and paying for freight while on-the-water. Other shipments have no data in this field, and it is too sparse to interpolate and thus only shipments with CIF were included above. CIF cost does NOT include customs / tariff costs.

Important features include “type”, customer, shipping distance

# Tariff Impact Analysis

Want to look at impacts of tariff announcements in 2025

Split data into “pre” and “post” periods, started with April 2nd, 2025, as the cut-off

Investigate changes in shipping patterns, based on departure port. “Country of Origin” not specifically available from data, need a commercial invoice, which are private business documents

Shipment Counts by Country - January 2020 through September 2025

| Country | Count | Percent (%) |
|---|---|---|
| China | 81,787 | 57.50 |
| Vietnam | 25,379 | 17.84 |
| Singapore | 8,412 | 5.91 |
| South Korea | 3,631 | 2.55 |
| Hong Kong | 2,067 | 1.45 |
| Italy | 2,044 | 1.44 |
| Indonesia | 1,646 | 1.16 |
| Germany | 1,577 | 1.11 |
| Taiwan | 1,568 | 1.10 |
| Denmark | 1,466 | 1.03 |

# Significant changes pre / post?

Seasonally-Adjusted Negative Binomial Tests

| Country | Pre→Post Rate | Change | Expected | Actual | p-value |
|---|---|---|---|---|---|
| Sri Lanka | 0.29→1.50 | +418.9% | 52.4 | 272 | 0.0000*** |
| South Korea | 1.80→3.62 | +100.7% | 326.4 | 655 | 0.0000*** |
| Belgium | 0.75→0.05 | -93.4% | 136.5 | 9 | 0.0000*** |
| Malaysia | 1.15→1.93 | +68.8% | 207.4 | 350 | 0.0007*** |
| Italy | 1.15→0.40 | -65.6% | 209.0 | 72 | 0.0000*** |
| Hong Kong | 0.68→0.32 | -53.2% | 124.0 | 58 | 0.0001*** |
| China | 62.26→29.64 | -52.4% | 11269.5 | 5364 | 0.0000*** |
| Spain | 0.62→0.36 | -42.4% | 112.8 | 65 | 0.0006*** |
| Indonesia | 0.80→1.08 | +35.7% | 144.4 | 196 | 0.1564 |
| Netherlands | 0.31→0.20 | -34.0% | 56.0 | 37 | 0.7299 |

The rate represents shipments per day. Pre: April-September 2022-2024; Post: April-September 2025

# Considering Weight

Rate-Adjusted Statistics (per day)

| Metric | Pre-Tariff | Post-Tariff | Change |
|---|---|---|---|
| Shipments/day | 92.34 | 62.00 | -32.9% |
| Total weight/day (kg) | 571,530 | 501,318 | -12.3% |

Per-Shipment Statistics

| Metric | Pre-Tariff | Post-Tariff | Change |
|---|---|---|---|
| Mean (kg) | 6,189.4 | 8,085.8 | +30.6% |
| Median (kg) | 4,863.0 | 6,486.0 | +33.4% |
| Std Dev | 7,840.6 | 8,447.6 | +7.7% |

Shipments / day down in the post period but average weight (kg) increased. Continue to see large variance per shipment – note shipment data is for the shoe shipments only; container ships have varied products on-board

# By Country

Weight by Origin Country (Apr–Sep Comparison, Sorted by p-value)

| Country | Ship/day | Change | Mean kg/ship | Change | Total kg/day | Change | p-value | r |
|---|---|---|---|---|---|---|---|---|
| Sri Lanka | 0.3 → 1.5 | +419.8% | 14782 → 6090 | -58.8% | 4273 → 9152 | +114.2% | 0.0000*** | +0.24 |
| China | 62.2 → 29.6 | -52.3% | 5906 → 8448 | +43.0% | 367264 → 250369 | -31.8% | 0.0000*** | -0.29 |
| Indonesia | 0.8 → 1.1 | +36.0% | 4781 → 11510 | +140.8% | 3807 → 12464 | +227.4% | 0.0000*** | +0.15 |
| South Korea | 1.8 → 3.6 | +100.6% | 7031 → 7898 | +12.3% | 12682 → 28580 | +125.4% | 0.0002*** | +0.18 |
| Vietnam | 14.0 → 14.9 | +6.5% | 6670 → 8177 | +22.6% | 93602 → 122210 | +30.6% | 0.0003*** | +0.18 |
| Spain | 0.6 → 0.4 | -42.2% | 5951 → 6269 | +5.3% | 3700 → 2251 | -39.2% | 0.0006*** | -0.14 |
| Hong Kong | 0.7 → 0.3 | -53.1% | 5361 → 4913 | -8.4% | 3665 → 1574 | -57.0% | 0.0008*** | -0.13 |
| Italy | 1.2 → 0.4 | -65.5% | 2362 → 2334 | -1.2% | 2727 → 928 | -66.0% | 0.0000*** | -0.18 |
| Netherlands | 0.3 → 0.2 | -33.9% | 4836 → 3916 | -19.0% | 1495 → 800 | -46.4% | 0.1399 | -0.04 |
| Germany | 0.8 → 0.8 | -0.6% | 9867 → 13159 | +33.4% | 7624 → 10106 | +32.5% | 0.1652 | -0.06 |

P-values based on Mann-Whitney U test, which is a non-parametric statistic test with null hypothesis that two samples are from the same distribution.  Uses rank of ordinal data.

# Route Shifting

Top Supplier → Origin Routes

| Route | Shipments |
|---|---|
| Indonesia → Singapore | 3,000 |
| Indonesia → China | 2,753 |
| Norway → Vietnam | 2,357 |
| Vietnam → China | 1,958 |
| Cambodia → Vietnam | 1,601 |
| China → South Korea | 1,091 |
| Indonesia → Malaysia | 994 |
| Indonesia → South Korea | 507 |
| Vietnam → Singapore | 479 |
| Cambodia → Singapore | 395 |

Total shipments: 102,111 (Apr-Sept '22-25 only)
Shipments where Supplier ≠ Origin: 20.4%

Route Shifting Rate Pre- vs Post-Tariff

| Period | Route Shift | No Shift | Total | Shift Rate (%) |
|---|---|---|---|---|
| Pre-tariff | 17,246 | 73,643 | 90,889 | 18.97 |
| Post-tariff | 3,550 | 7,672 | 11,222 | 31.63 |

Change: +12.66 percentage points
Chi-square test: $\chi 2 = 986.26$, $p = 0.0000$
Conclusion: Route shifting increased significantly post-tariff announcement

# Chinese Suppliers Only

Origin Distribution (Same-Month Apr–Sep Comparison)

| Origin Country | Pre/day | Post/day | Change | Change % |
|---|---|---|---|---|
| China | 57.45 | 24.64 | −32.82 | −57.1% |
| South Korea | 0.74 | 1.67 | +0.94 | +126.9% |
| Germany | 0.00 | 0.37 | +0.37 | NEW |
| Vietnam | 0.00 | 0.28 | +0.27 | +7482.9% |
| Canada | 0.00 | 0.09 | +0.09 | NEW |
| Malaysia | 0.02 | 0.08 | +0.05 | +226.6% |
| Spain | 0.03 | 0.07 | +0.04 | +146.4% |
| Singapore | 0.02 | 0.06 | +0.04 | +175.7% |
| Taiwan | 0.07 | 0.06 | −0.02 | −26.0% |
| Sri Lanka | 0.00 | 0.04 | +0.04 | NEW |

Non-China Origin Shifts of Chinese Suppliers

| Category | Pre (per day) | Post (per day) | Daily Change (%) |
|---|---|---|---|
| Non-China origins | 1.10/day | 2.93/day | +1.82 (+165.3%) |
| China origin | 57.46/day | 24.64/day | −32.82 (−57.1%) |

Shipment Counts (Shipments/day)

| Category | U | p-value | 95% CI |
|---|---|---|---|
| Non-China routing | 67,740 | $5.25e^{-15}$ | [1.25, 2.45] |
| China direct | 26,386 | $2.78e^{-21}$ | [−39.28, −26.99] |

Weight (KG/day)

| Category | U | p-value | 95% CI (KG) |
|---|---|---|---|
| Non-China routing | 68,917 | $1.21e^{-16}$ | [14,487, 30,641] |
| China direct | 31,715 | $2.80e^{-13}$ | [−156,149, −99,195] |

Both statistical tests indicate there is sufficient evidence that there are differences in the distribution of pre / post data for both shipment counts and weight

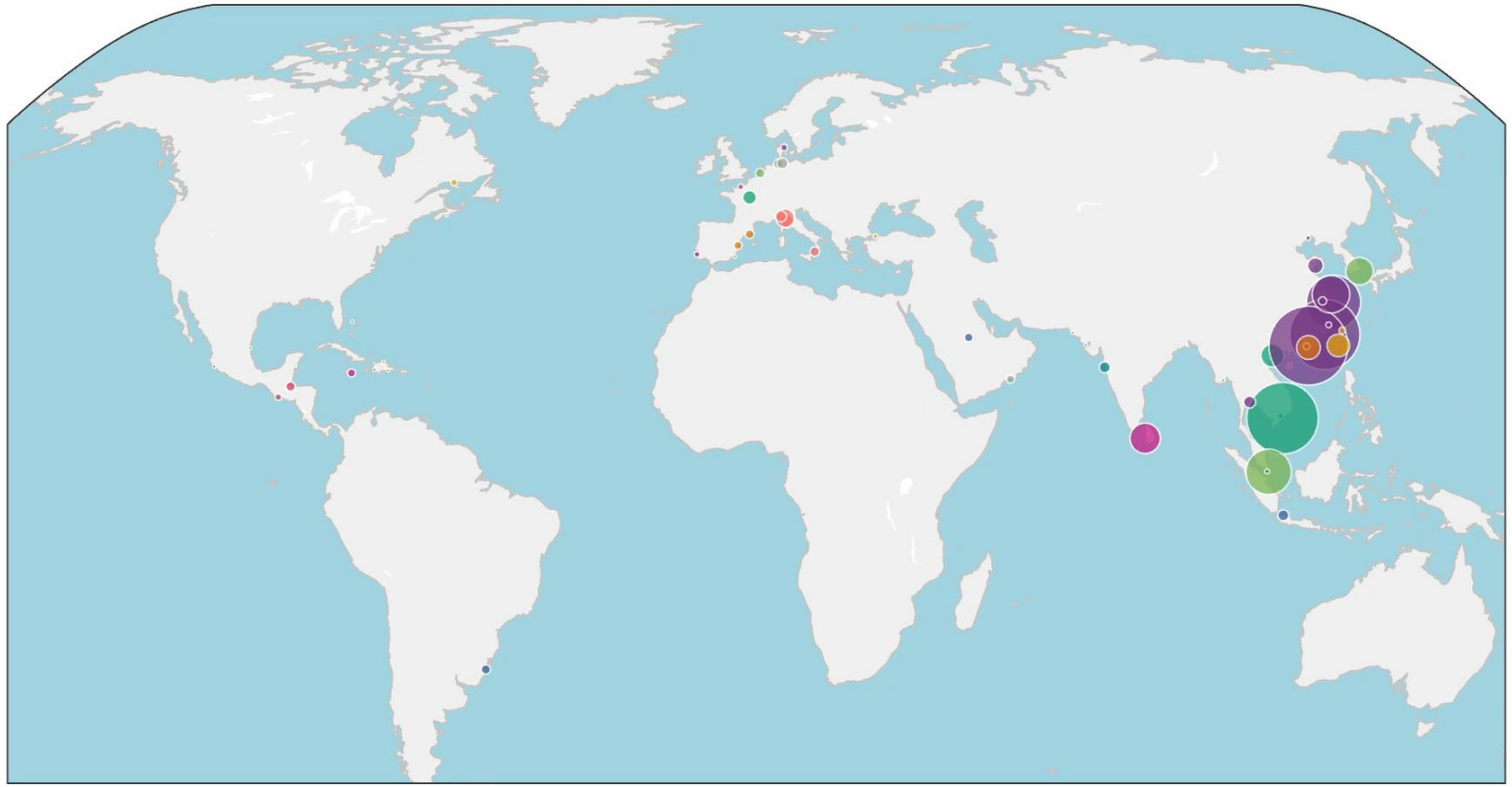
# Considerations

Need to be cautious when attributing changes in routes and shipment counts to tariff actions due to legal implications.

Should consider other timeframes as changes in business are common.

This is a starting point to other research in business operations.  Other products that were specifically targeted can be reviewed.  In depth customer and supplier analysis can also be performed.

Shipments from Departure Ports Over Time



Country
DK
VN
BR
CA
GT
SG
ES
IN
LK
JP
OM
CN
PK
BS
TR
FR
KR
HK
MX
PT
IT
DE

Period=2020-01

2020-01 2020-05 2020-09 2021-01 2021-05 2021-09 2022-01 2022-05 2022-09 2023-01 2023-05 2023-09 2024-01 2024-05 2024-09 2025-01 2025-05 2025-09

# Thank You

Blair Jones

blair.jones@colorado.edu

323-810-5633