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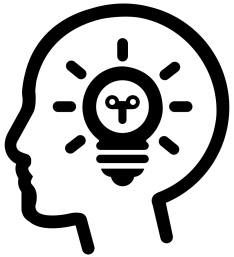
SOLAR TURBINES



Optimizing Shipping Efficiency and Cost: Data-Driven Insights for Solar Turbines

Sam Angeles, Daniel Atlan, Betty Hagos, Ben Keefer, Anthony Lantiere

May 9th, 2024

MEET THE TEAM

Sam Angeles

Daniel Atlan

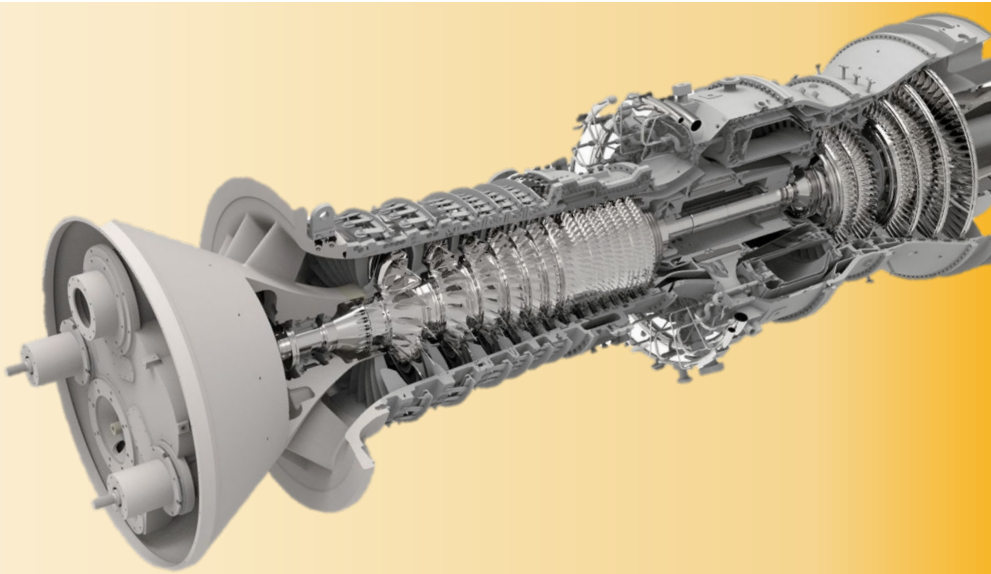
Betty Hagos

Ben Keefer

Anthony Lantiere

AGENDA

1. Introduction
2. Data Overview
3. Methodology
4. Accessorial Charge Codes
5. Machine Learning
6. Interactive Dashboards
7. Limitations
8. Recommendations
9. Conclusions



01

INTRODUCTION

PRIMARY CHALLENGES

Derive actionable insights for solar turbines scm team to optimize operational efficiency and shipping costs:

- Comprehensive data cleaning, exploration, and merging
- Trend analysis and insight extraction
- Machine learning model creation
- Charge code mapping

OBJECTIVES

1. Deliver insights and tools that can be used for further analysis
2. Identify methods to improve operational efficiency
3. Pinpoint locations in the supply chain (shipment process) for cost reduction
4. Create methods to predict costs and minimize financial risk

02

DATA OVERVIEW

AND LIMITATIONS

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DATASET 1: FREIGHT

Larger shipments over 150 pounds including information on price, origin, destination, mileage, and size of the shipment. Provides insight to geographical information and cost for shipments.

Key Variables

- Adjusted Amount Paid
- Mileage
- Ship Weight
- Carrier Name

Dataset Overview	
# of Observations	171,150
# of Variables	23

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DATASET 2: PARCEL

Smaller shipments under 150 pounds including information on price, destination, origin, and size of the shipment. Provides insight to smaller shipments and cost factors.

Key Variables

- Accessorial Amount
- Carrier Name
- Height, Length, Width, Weight
- Total Paid

Dataset Overview	
# of Observations	490,962
# of Variables	22

DATASET 3: ACCESSORIAL

Detailed accessorial charges for shipments between freight and parcel shipping types. Provides deeper understanding for charges incurred by shipment.

Key Variables

- Accessorial Amount
- Accessorial Charge Code
- Accessorial Charge Description

Dataset Overview	
# of Observations	278,587
# of Variables	30

DATASET 4: EDI

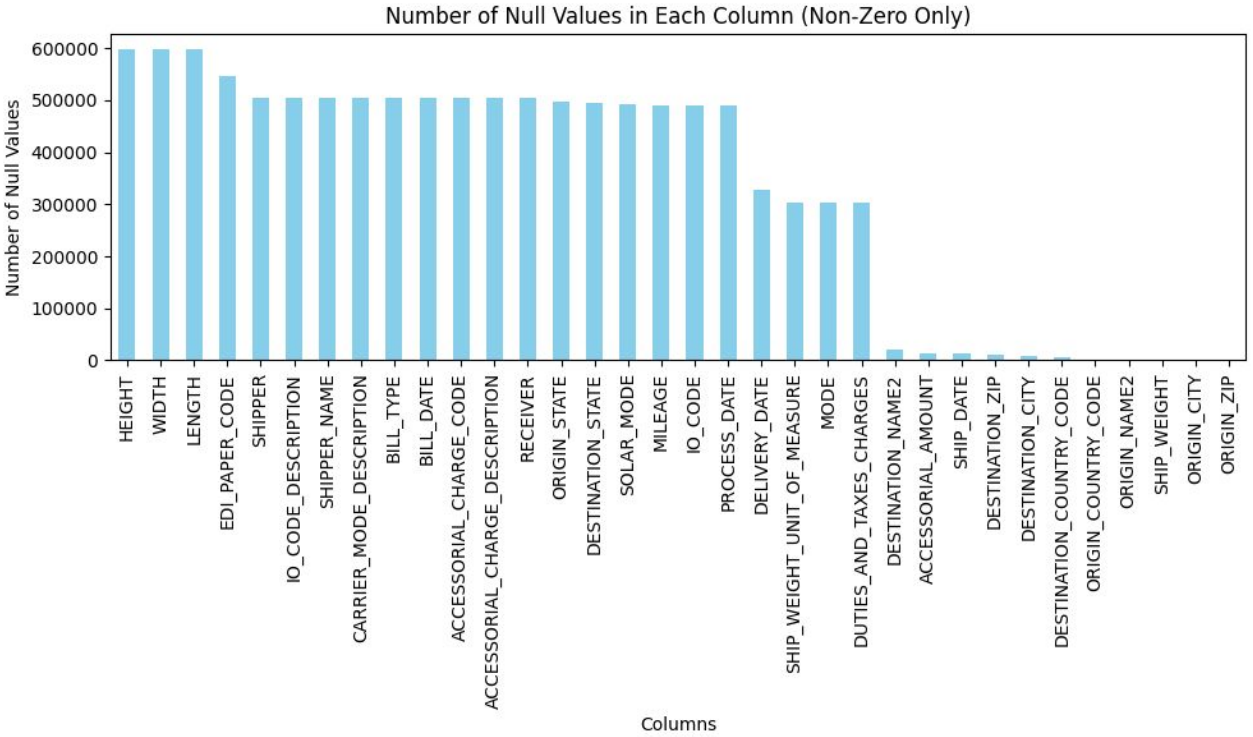
Provided additional information about invoices being stored with paper or electronically.

Key Variables

- Carrier Name
- Amount Paid
- EDI Paper Code

Dataset Overview	
# of Observations	169,510
# of Variables	4

DATA EXPLORATION



LIMITATIONS

EXTREME VALUES

NULL VALUES

ANONYMIZATION

INCOMPLETENESS

CONSISTENCY

03

METHODOLOGY

FRAMING THE PROBLEM

THREE-PRONGED APPROACH

ACCESSORIAL CHARGE CODE **MAPPING**

INTERACTIVE DASHBOARDS FOR IDENTIFYING SHIPPING COST DYNAMICS

MACHINE LEARNING FOR PREDICTING ACCESSORIAL CHARGES

04

ACCESSORIAL CHARGE CODES

ACCESSORIAL CHARGE CODES

TWO-LETTER COMBINATIONS

- CONFUSING AND LACKS DIRECTION
- USERS NEED TO KNOW ALL LETTER COMBINATIONS

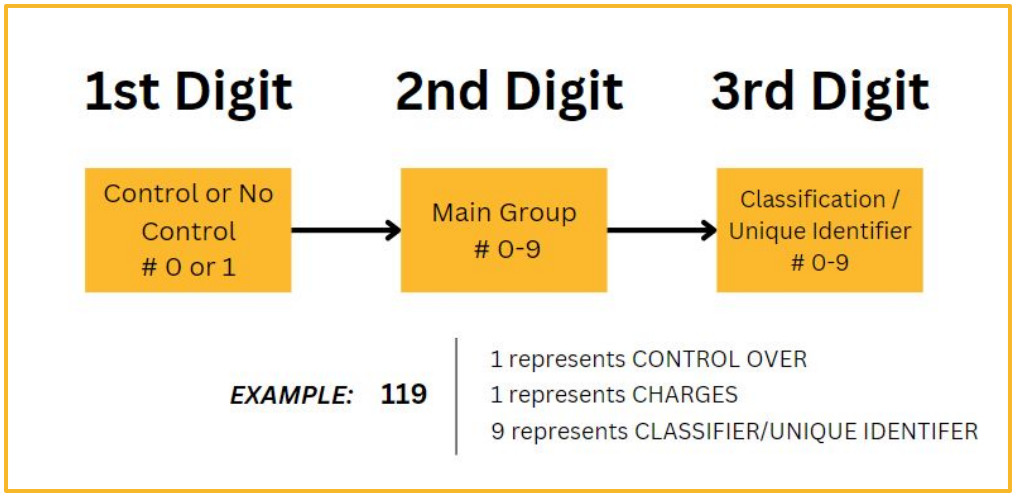
138

ACCESSORIAL CHARGE CODES

ACCESSORIAL CHARGE CODES SOLUTION

3-DIGIT CHARGE INDEX

- REIMAGINE CODES INTO HYPOTHETICAL 3-DIGIT CODES
- EACH DIGIT PROVIDES MEANINGFUL CLASSIFICATION



3-DIGIT MAPPING

23

ACCESSORIAL CHARGE CODES REPRESENT

94.14%

OF ALL ACCESSORIAL CHARGES

RECLASSIFIED 23 ACCESSORIAL CHARGE CODES INTO 23 UNIQUE 3-DIGIT CODES

3-DIGIT MAPPING

FIRST DIGIT:

- 0 → SOLAR TURBINES HAS NO CONTROL OVER
- 1 → SOLAR TURBINES HAS CONTROL OVER
- 2 → NEEDS TO BE REVIEWED AND CATEGORIZED

SECOND DIGIT:

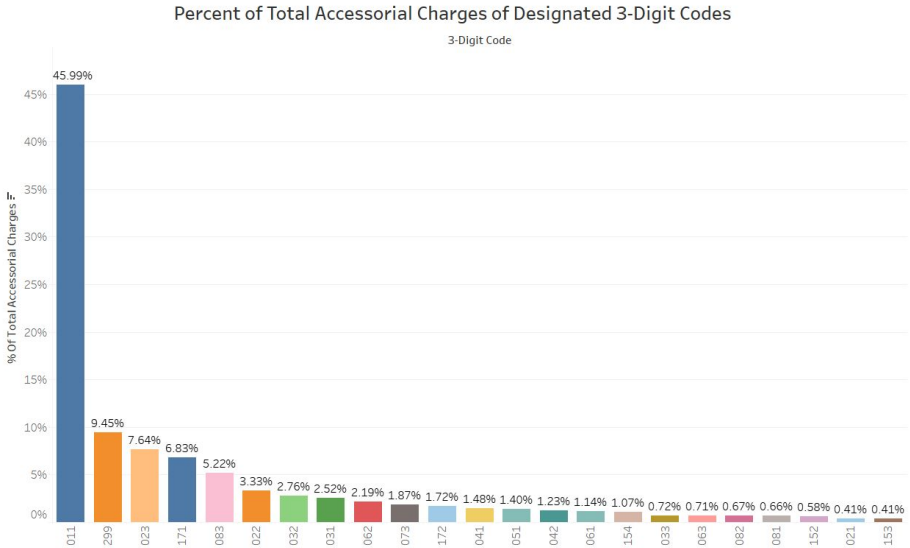
- 1 → FUEL SURCHARGES
- 2 → HANDLING & CARRYING
- 3 → GOVERNMENT IMPOSED
- 4 → MOVING & TRANSFERRING
- 5 → STORAGE & OUTSIDE TIME
- 6 → ADMINISTRATIVE
- 7 → EXTRA FEES
- 8 → BROKERAGE
- 9 → MISCELLANEOUS

3-Digit Code Classification	First Digit	Second Digit	Third Digit	Accessorial Charge Code	Accessorial Charge Description	3-Digit Code	
No Control Over	0	1	1	FS	FUEL SURCHARGE	011	128,128
		2	1	HA	HANDLING	021	14,551
			2	PC	PICK UP	022	10,135
			3	EE	EXPORT/DOMESTIC PACKING	023	1,148
		3	1	DU	DUTY CHARGES	031	9,265
			2	PF	PROCESSING FEE/MERCHANDI..	032	7,010
			3	EC	EXTRA COPIES MAILING	033	4,134
		4	1	TH	TERMINAL SERVICE	041	7,685
			2	TF	AIRPORT TRANSFER FEE	042	3,171
		5	1	TA	TARP	051	4,786
		6	1	MN	MANIFEST	061	6,112
			2	AM	ADMINISTRATION FEE	062	3,426
			3	DA	DUTY ADVANCE	063	1,855
		7	3	HZ	HAZARDOUS MATERIAL FEE	073	1,972
		8	1	AF	AES FILING FEE/CLEARANCE	081	1,838
			2	SU	SECURITY CHARGE	082	2,981
			3	BR	CUSTOM BROKERAGE CHARGE	083	21,290
Control Over	1	5	2	DH	DELIVERY CHARGE POINT	152	3,891
			3	ST	STORAGE	153	2,013
			4	DT	DETENTION	154	1,624
		7	1	OL	OUT OF AREA DELIVERY	171	1,137
			2	WV	WEIGHT VERIFICATION	172	5,199
Miscellaneous	2	9	9	MS	MSC CHRGS	299	19,033

THIRD DIGIT:

UNIQUE IDENTIFICATION NUMBER FOR EACH GROUPING OF ACCESSORIAL CHARGE CODES

3-DIGIT MAPPING



BENEFITS:

- SIMPLIFIED SYSTEM WITH ONLY 23 CODES TO MEMORIZE
- CLEAR AND EASY FILING PROCESS
- MEANINGFUL CONCEPT BEHIND CODE STRUCTURE
- ENHANCES UNDERSTANDING AND EFFICIENCY IN MANAGING ACCESSORIAL CHARGES

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EXAMPLE: FINANCIAL IMPACT OF 3-DIGIT MAPPING

FINANCIAL IMPACT OF IN-CONTROL ACCESSORIAL CHARGES (100s)	
COST OF DELIVERY CHARGE POINT (152)	$5,756,929.08
COST OF STORAGE (153)	$4,610,288.84
COST OF DETENTION (154)	$2,499,137.86
COST OF OUT OF AREA DELIVERY (171)	$146,847.24
COST OF WEIGHT VERIFICATION (172)	$143,093.75
TOTAL COST OF IN-CONTROL CHARGES	**$13,156,296.77**

DECREASING TOTAL IN-CONTROL CHARGES BY

1%

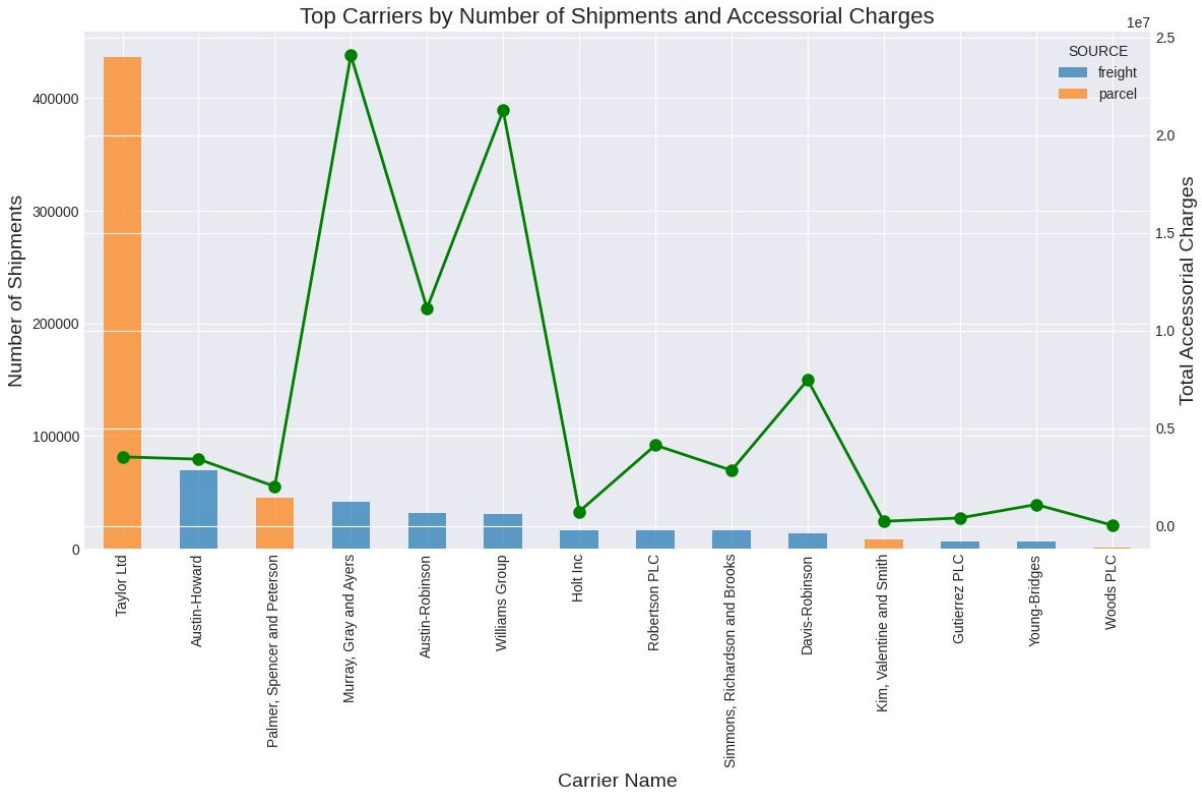
CAN LEAD TO POTENTIAL COST SAVINGS OF

$131,562.97

05

MACHINE LEARNING

PRIMARY CARRIER'S FOR SHIPPING



REGRESSION (PARCEL)

CARRIER	AVG. COST
TAYLOR LTD	$8.09
ALL OTHERS	$45.56
DIFFERENCE	$37.47
TRUE COST *REGRESSION WITH VARIABLES*	**$14.76**

GIVEN

28,574

NON-TAYLOR LTD. SHIPMENTS

POTENTIAL COST SAVINGS BY SWITCHING TO TAYLOR LTD. ARE ESTIMATED AT

$421,752.24

REGRESSION (FREIGHT)

CARRIER	AVG. COST
AUSTIN-HOWARD	$48.89
ALL OTHERS	$1045.26
DIFFERENCE	$996.37
TRUE COST *REGRESSION WITH VARIABLES*	**$53.80**

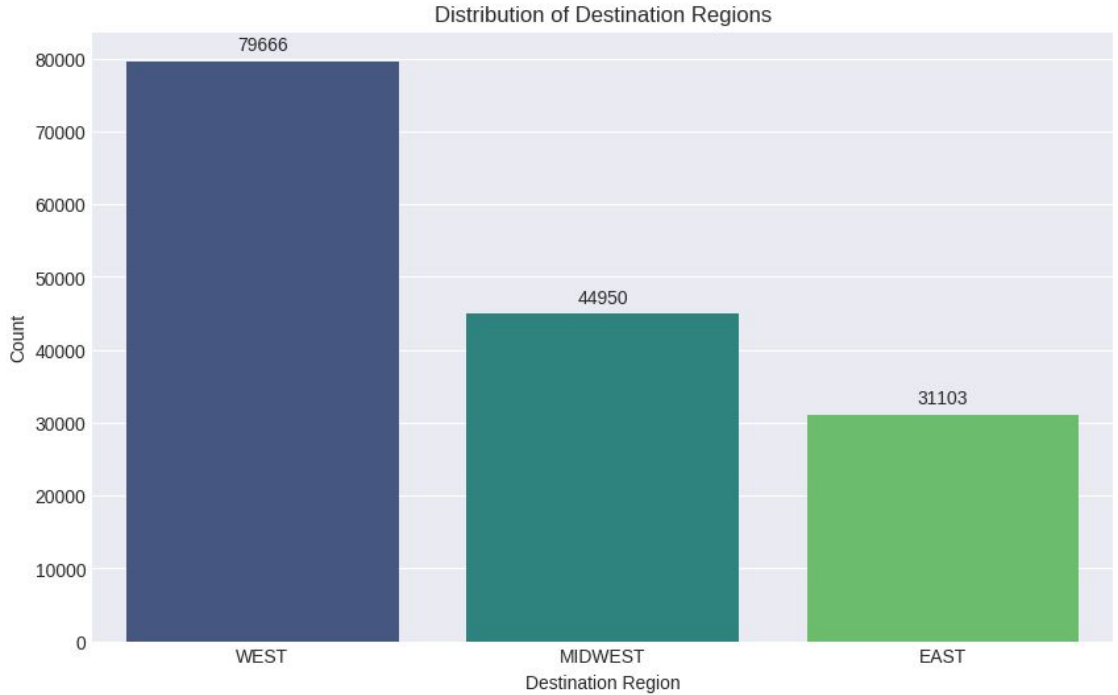
FOR EVERY CARRIER USED THAT IS NOT AUSTIN-HOWARD COST INCREASES BY $00.16/MILE

BY SWITCHING TO USE AUSTIN-HOWARD AS THE SOLE CARRIER, POTENTIAL COST SAVINGS ARE ESTIMATED AT

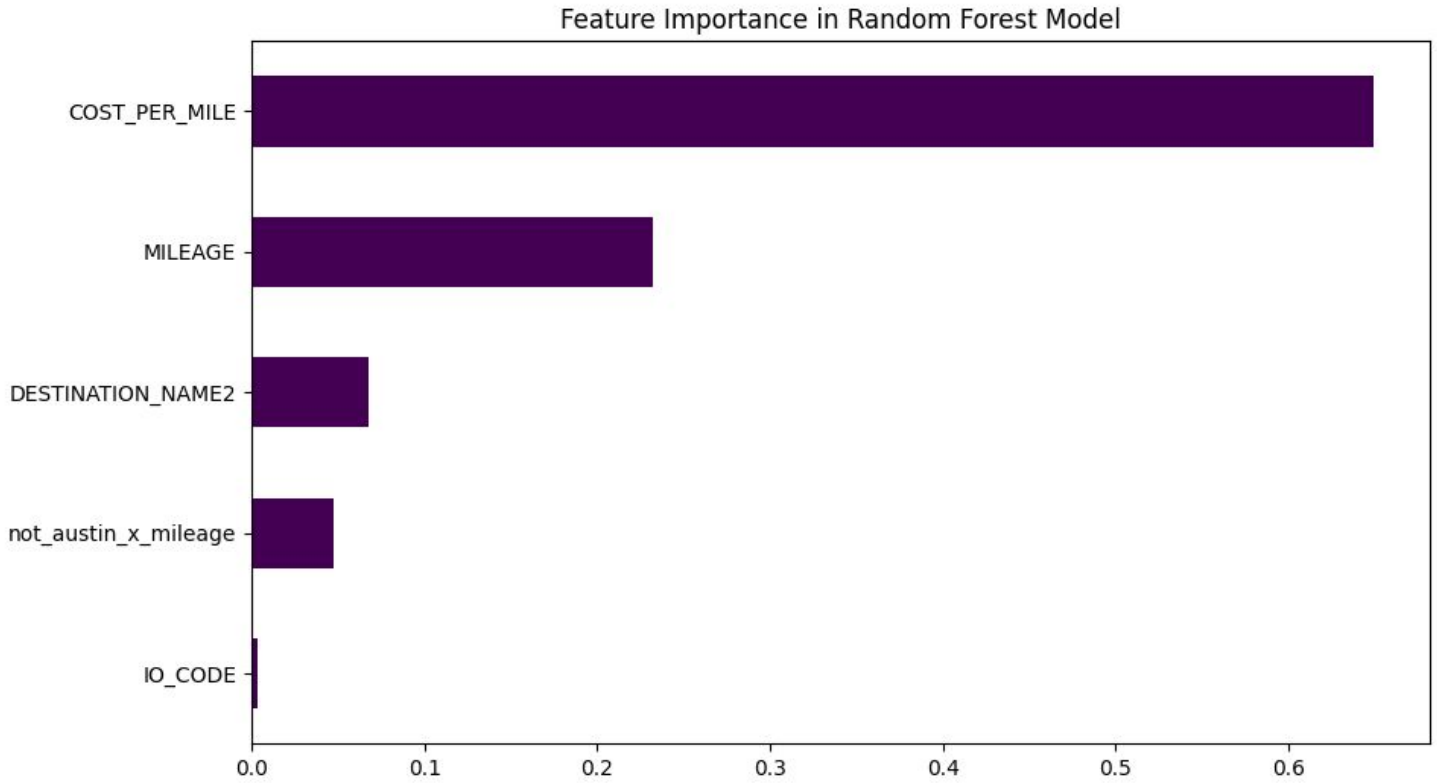
$99,762.00

MACHINE LEARNING METHODOLOGY

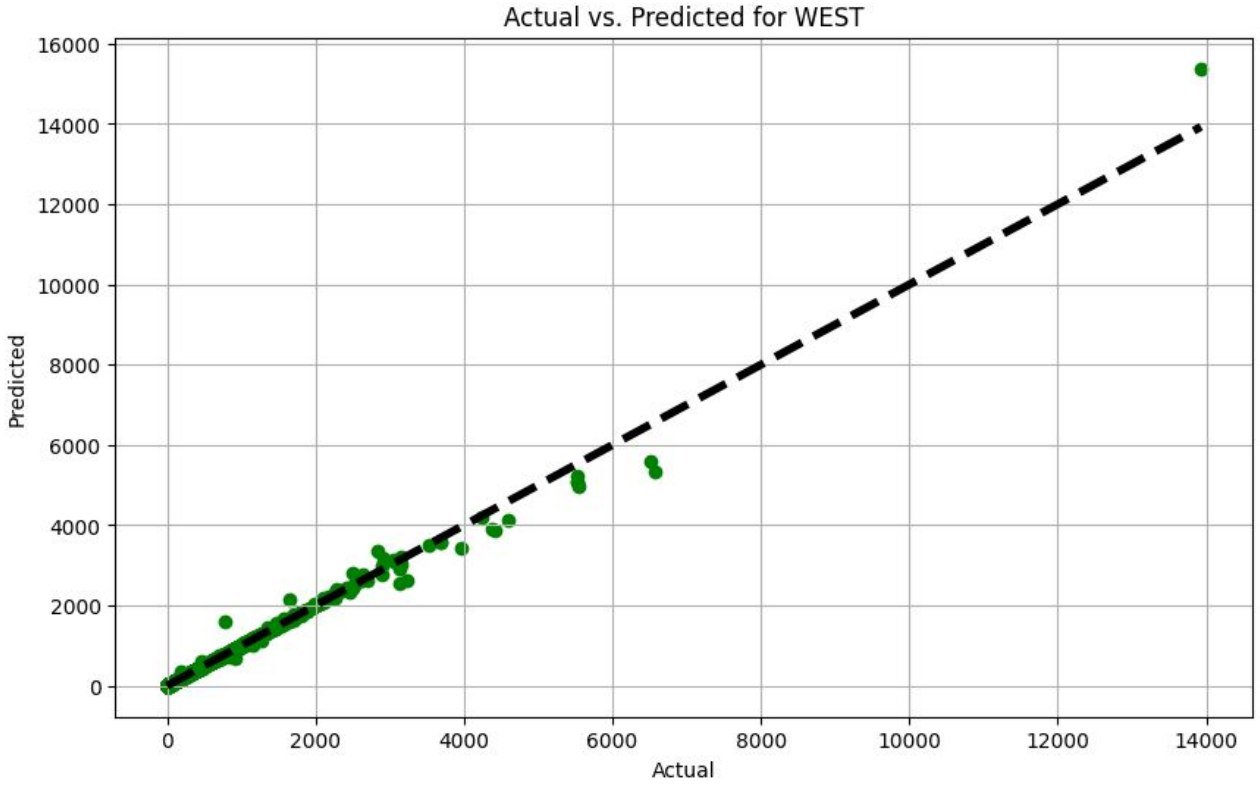
USED DOMESTIC US FREIGHT SHIPMENTS ABOVE 20 MILES TO EXCLUDE OUTLIERS/ NULL MILEAGE VALUES



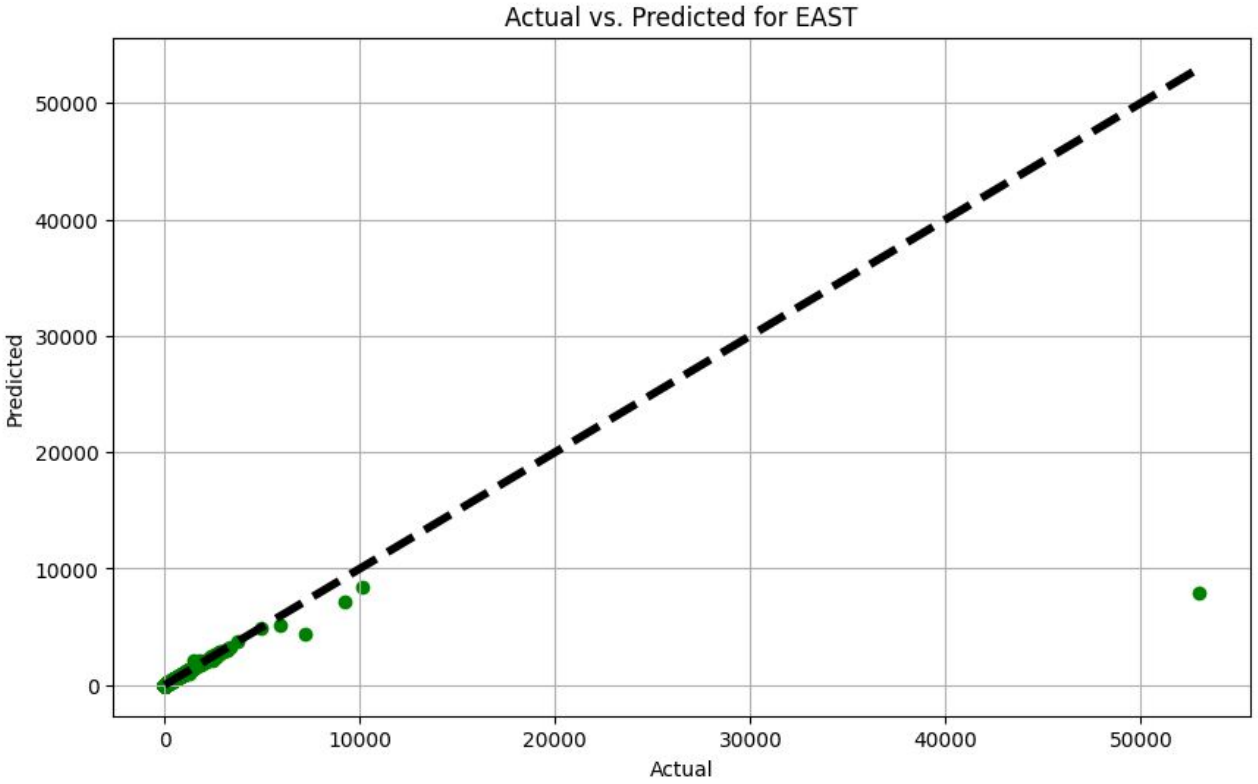
MACHINE LEARNING MODEL



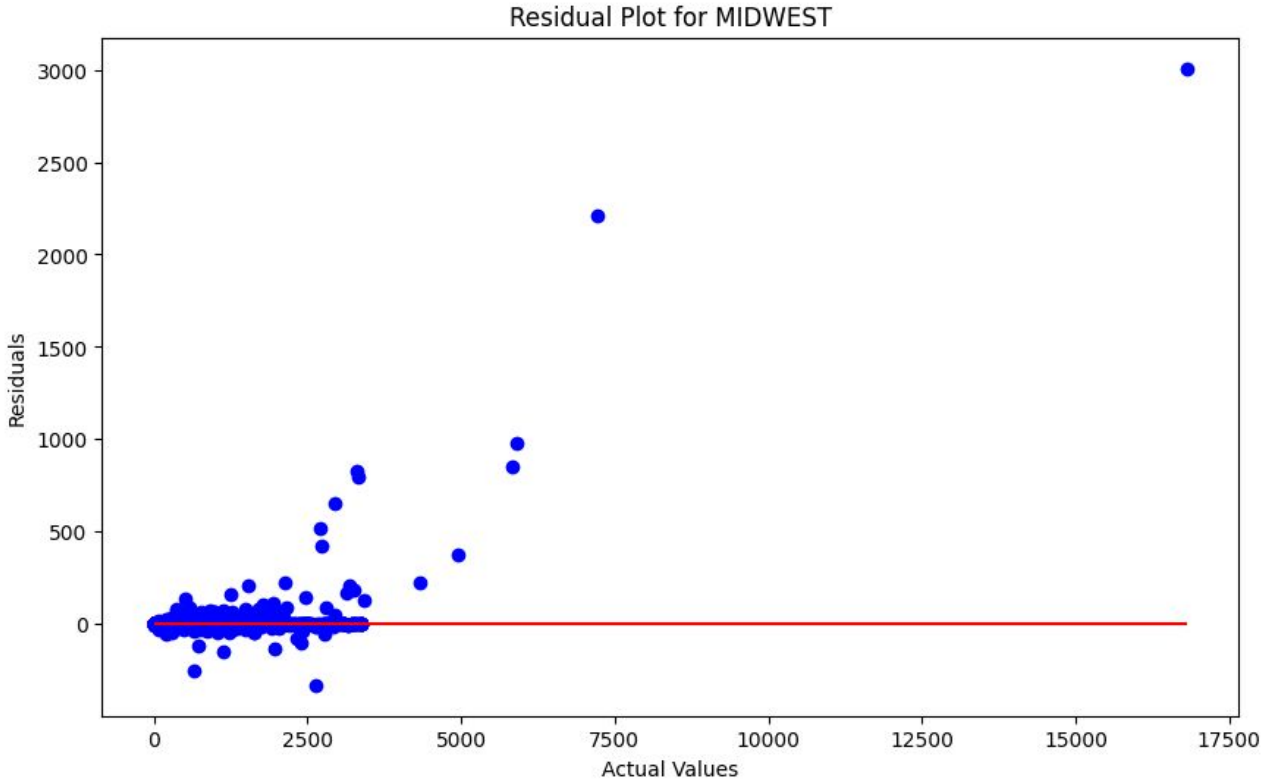
MACHINE LEARNING MODEL



MACHINE LEARNING MODEL



MACHINE LEARNING MODEL



06

INTERACTIVE DASHBOARDS

INTERACTIVE DASHBOARD

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Cost Overview

Total Accessorial Charge Trends By Year And Quarter

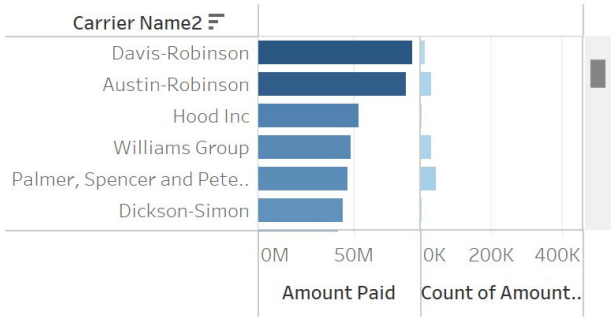
Carrier Name2
(All)

Highlight Year of Ship Date
Highlight Year of Ship Date

Highlight Carrier Name2
Highlight Carrier Name2

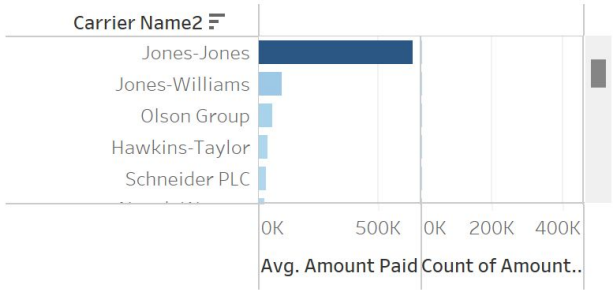
Total Amount Paid By Carrier

Total Shipping Charges Paid Broken Down By Specific Carriers



Average Amount Paid By Carrier

Average Total Charge Per Shipment Broken Down By Specific Carrier



Overall **average accessorial charges have been increasing** year over year

Years 2022 and 2023 have been exhibiting increasing avg accessorial charge trends throughout each year

Carrier Davis-Robinson has highest total amount paid for shipments

Carrier Jones-Jones has highest avg amount paid for shipments

Carrier Taylor Ltd has highest count of shipments

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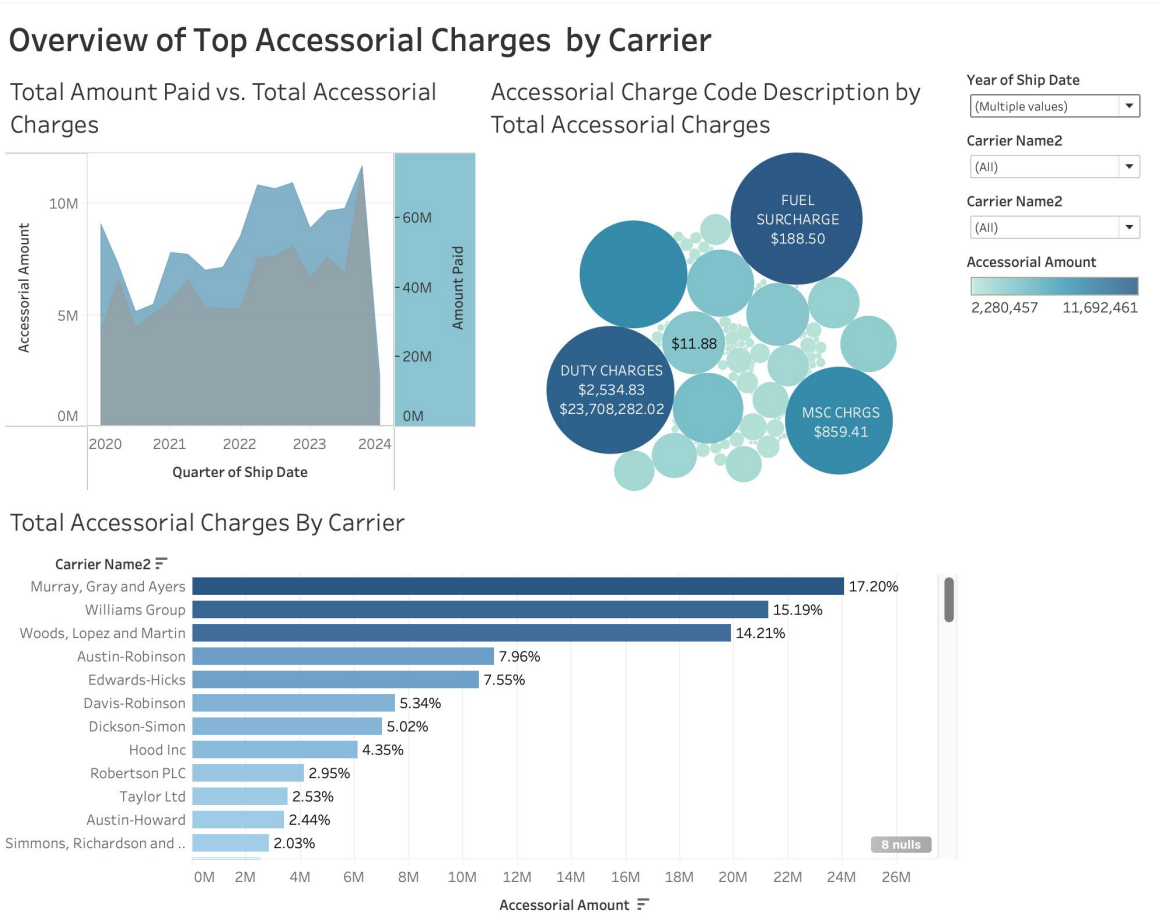

Years 2022 to 2024 have been exhibiting increasing accessorial charge and amount paid trends throughout each year

Carrier Murray, Gray and Ayers has highest total accessorial charges for shipments

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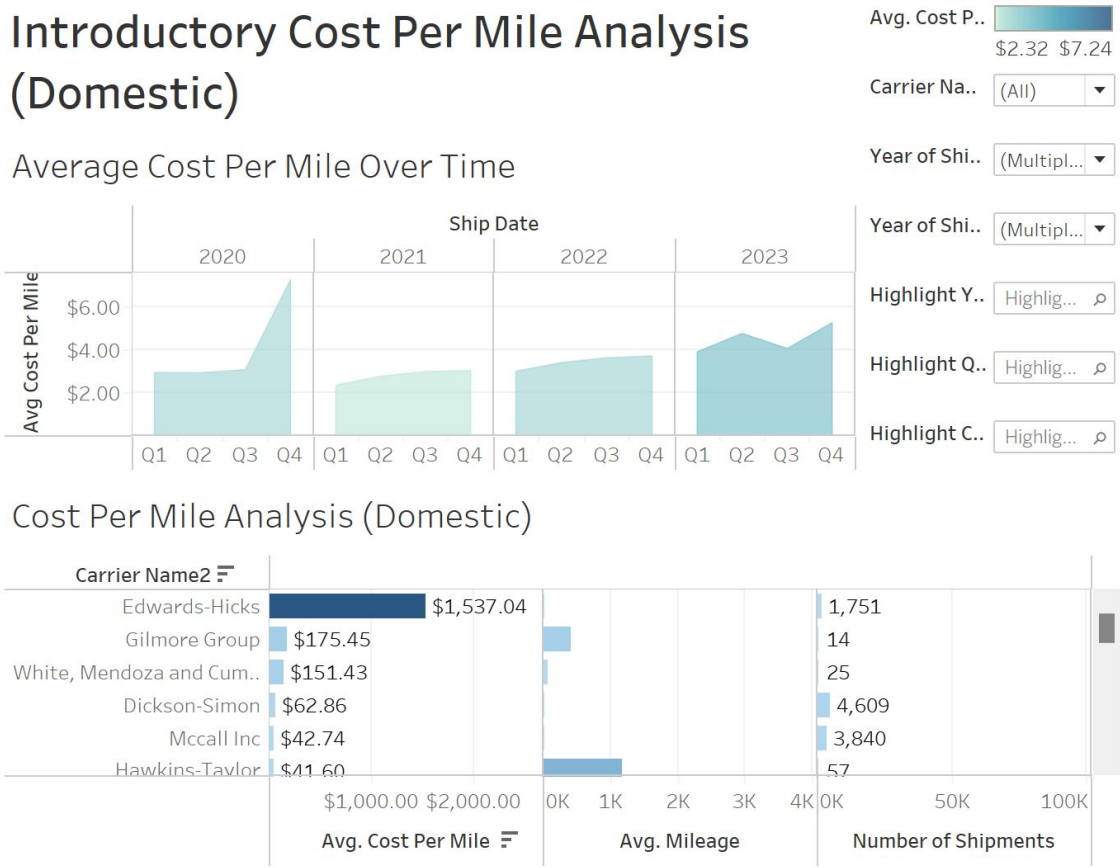

Overall **average cost per mile has been increasing** since the start of 2021

All quarters exhibit an **increasing average cost per mile with the highest averages sitting in the 4th quarter**

Carrier **Edwards-Hicks has the highest average cost per mile** for shipments

Shipments with carrier **Mcneil, Frank and Wise tend to have the highest average mileage**

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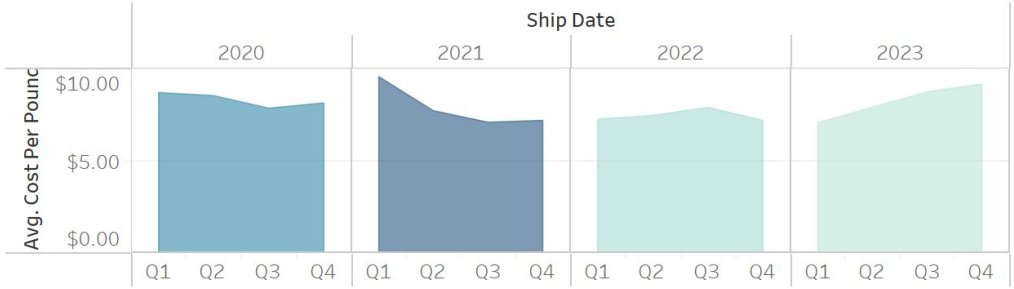
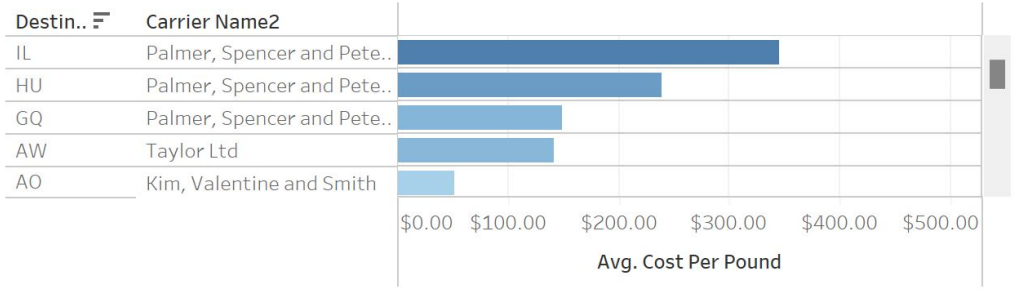
Introductory Cost Per Pound Analysis (International)

Average Cost Per Pound over Time



Average Cost Per Pound By Destination Country



Destination Country Code
(Multiple values)

Destination Country Code
(All)

Highlight Destination Cou..
Highlight Destination ...

Highlight Carrier Name2
Highlight Carrier Nam...

For international shipments overall **average cost per pound has been increasing** since Q2 of 2021

Avg cost per pound now **trending higher in the last two quarters of the year**

Shipments to **Israel and Hungary** have been demanding the highest average cost per pound

INTERACTIVE DASHBOARD

GLOBAL CARRIER COMPARISON

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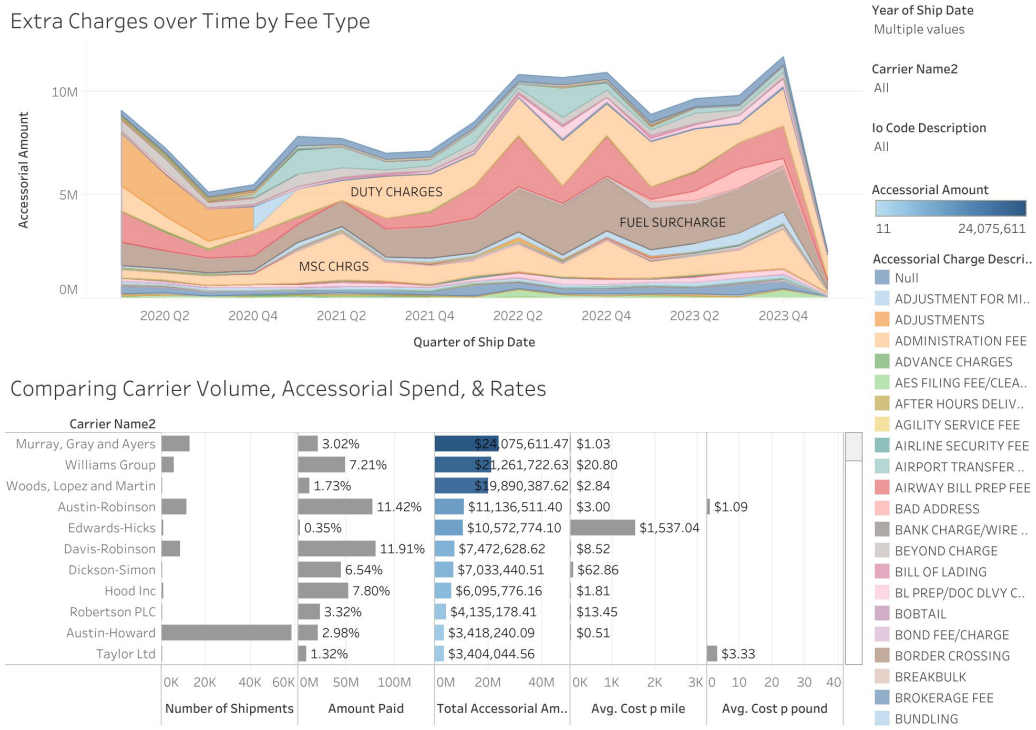
Global Overview of Costs - Carrier Spend, Top Total Accessorial Amounts, Average Cost Per Mile, and Average Cost Per Lb



Trend shows **accessorial charges increase every year between Q1 to Q2** consistently

Fuel surcharge has been accruing higher percent of charges since 2021

Carrier **Austin-Howard** has significantly more shipments but only charges $0.51 per mile

While **Edward-Hicks** is charging $1,537 per mile

INTERACTIVE DASHBOARD

ISOLATING CARRIER, MODE & SPEND BY CHARGE TYPE

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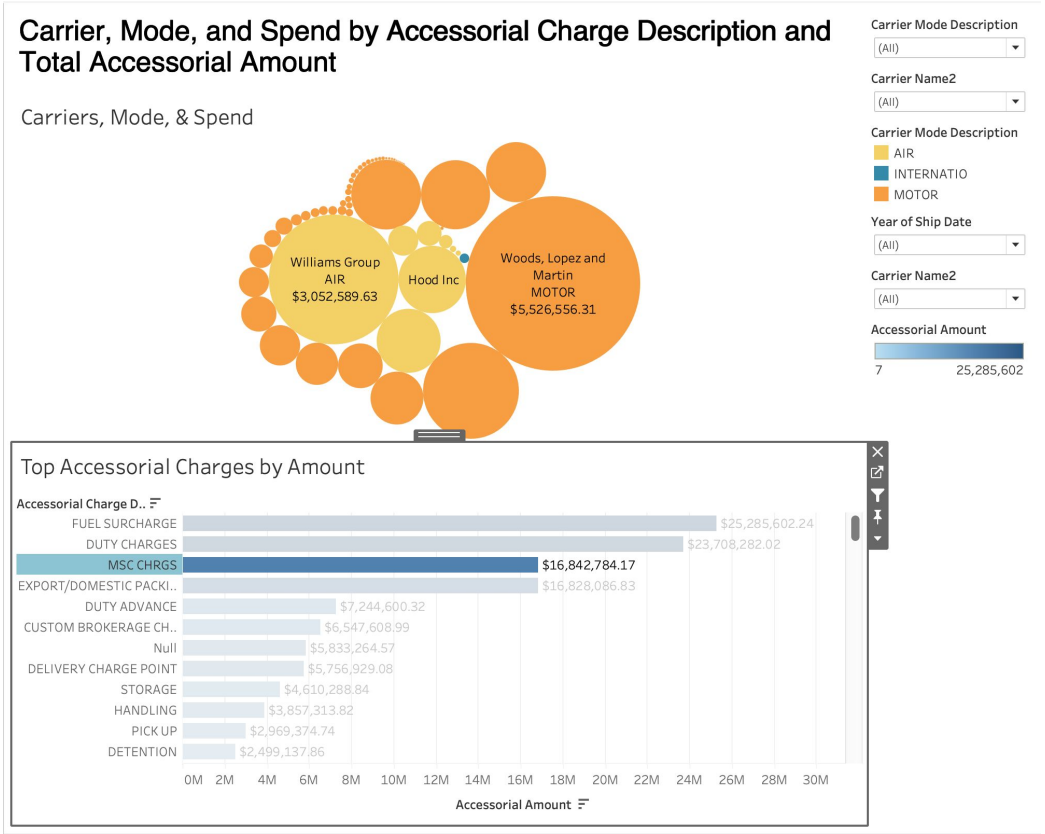


Woods, Lopez, and Martin is spending over $5 million in motor shipping

Williams Group is spending over $3 million in air shipping

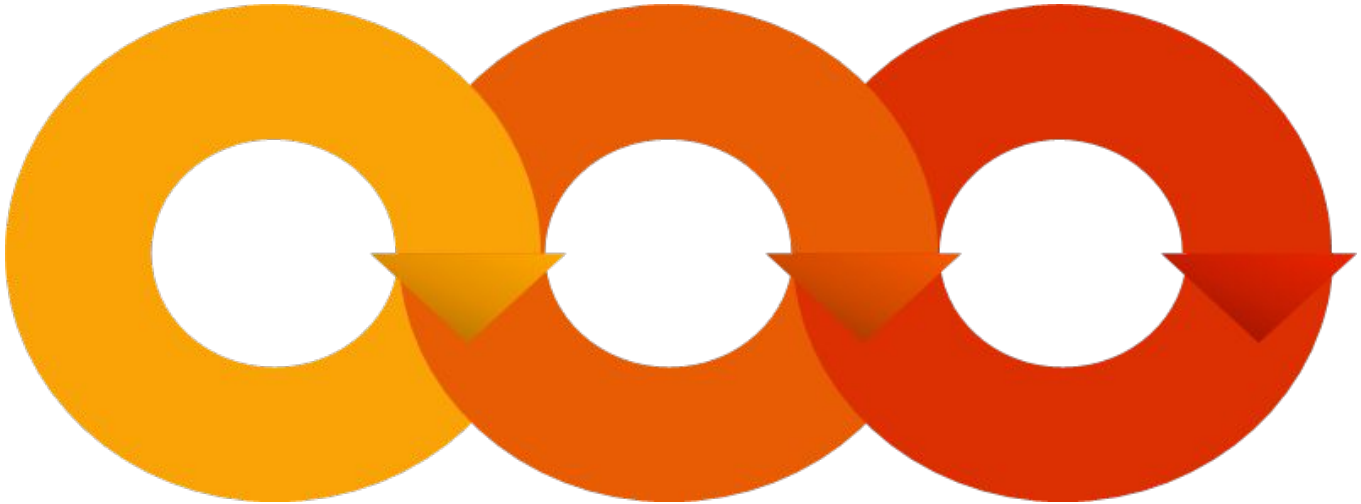
Miscellaneous charges account for over $16 million between 2020-2023

07

LIMITATIONS

ON OUR FINDINGS

LIMITATIONS



1

HISTORICAL DATA
(2020 - PRESENT)

2

Data Anonymization

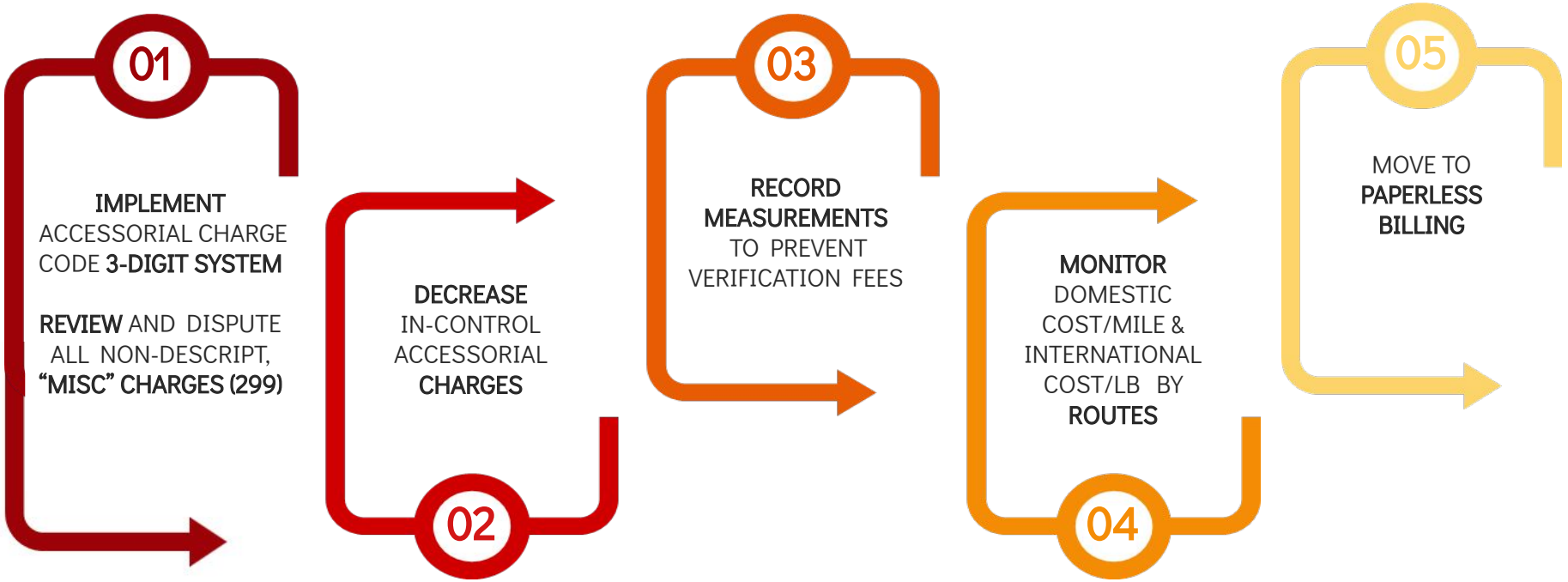
3

Data Inconsistency and
Incompleteness

08

RECOMMENDATIONS

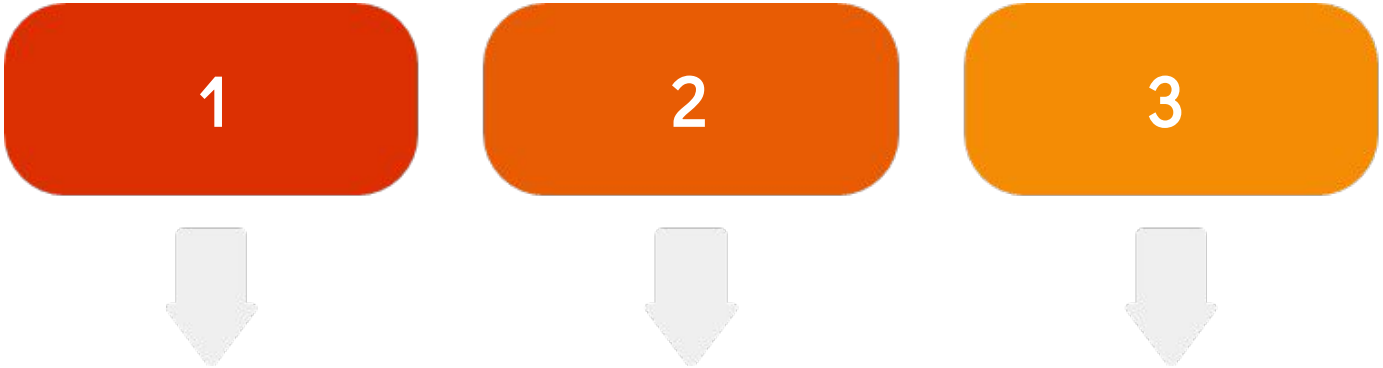
RECOMMENDATIONS



09

CONCLUSION

CONCLUSION



3-Digit Code system streamlines classification and filing processes, enhancing efficiency in managing accessorial charges

$521,514 potential cost savings by using carriers Austin-Howard & Taylor Ltd.

Package of **interactive dashboards** for SCM team to use for further trend analysis and cost evaluations

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THANK YOU

QUESTIONS?

APPENDIX

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MSBA CAPSTONE PROJECT GOALS

- APPLY STATISTICAL, DATA VISUALIZATION, AND MACHINE LEARNING TECHNIQUES TO ANALYZE THE DATA.
- IDENTIFY PATTERNS, TRENDS, INSIGHTS THAT CAN HELP ADDRESS THE CURRENT BUSINESS PROBLEMS.
- CREATE A DASHBOARD OR A MODEL THAT THE ORGANIZATION CAN USE IN THE FUTURE.
- PROVIDE ACTIONABLE RECOMMENDATIONS OR STRATEGIES BASED ON THE DATA-DRIVEN ANALYSIS TO ADDRESS THE BUSINESS PROBLEMS.
- QUANTIFY THE POTENTIAL IMPACT OF IMPLEMENTING THE RECOMMENDATIONS OR SOLUTIONS DERIVED FROM THE ANALYSIS THROUGH WELL-ESTABLISHED METRICS.

SOLAR TURBINES PROJECT SCOPE

Data Management Solution: Data Quality Control & 3-Digit Index

- Accuracy
- Consistency
- Efficiency

Data Visualization Solution: Tableau Dashboard

- Live
- Interactive
- Informative

Business Insights Solution: Shipment Segmentation

- Negotiation
- Prioritization
- Optimization

DATA DESCRIPTION

accessorial → 30 variables, over 270,000 observations

- Overall view of shipping information including accrued charges, shipping weights, types, and sending and receiving locations.

EDI → 4 variables, over 160,000 observations

- It includes the carrier and the transaction amount. This dataset contains a significant amount of null values which come from parcel shipping as bigger shipping companies have their own tracking information.

freight → 25 variables, over 170,000 observations

- Dataset includes larger items being shipped outside of a separate mailing service. Dataset includes information regarding charges accrued through shipping along with shipping information, dates, and destination of items.

parcel → 23 variables, over 490,000 observations

- Dataset includes information on smaller items shipped through the mail with prices, dates and origin and destination. Dataset also has its own tracking number along with the carrier and miles being shipped.

ADDRESSING THE PROBLEMS

Tool	New Accessorial Charge Index	Interactive Dashboards of Shipping Cost Dynamics	Machine Learning Model
Why?	To streamline the charge classification and billing management process To empower stakeholders to monitor, contextualize & negotiate fees To facilitate downstream analytics processing	To highlight areas within the shipping process in need of attention To allow for dynamic filtering and exploration of complex patterns To offer trend analysis tools for future investigation	To enable advanced analytics To prioritize charges in need of human review To inform negotiations

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ACCESSORIAL CHARGE CODE 3-DIGIT MAPPING

3-Digit Code Classification	First Digit	Second Digit	Third Digit	Accessorial Charge Code	Accessorial Charge Description	3-Digit Code	
No Control Over	0	1	1	FS	FUEL SURCHARGE	011	128,128
		2	1	HA	HANDLING	021	14,551
			2	PC	PICK UP	022	10,135
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		5	1	TA	TARP	051	4,786
		6	1	MN	MANIFEST	061	6,112
			2	AM	ADMINISTRATION FEE	062	3,426
			3	DA	DUTY ADVANCE	063	1,855
		7	3	HZ	HAZARDOUS MATERIAL FEE	073	1,972
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Control Over	1	5	2	DH	DELIVERY CHARGE POINT	152	3,891
			3	ST	STORAGE	153	2,013
			4	DT	DETENTION	154	1,624
		7	1	OL	OUT OF AREA DELIVERY	171	1,137
			2	WV	WEIGHT VERIFICATION	172	5,199
Miscellaneous	2	9	9	MS	MSC CHRGS	299	19,033

REGRESSION (PARCEL)

OLS Regression Results

Dep. Variable:	ACCESSORIAL_AMOUNT	R-squared:	0.171
Model:	OLS	Adj. R-squared:	0.171
Method:	Least Squares	F-statistic:	4848.
Date:	Fri, 03 May 2024	Prob (F-statistic):	0.00
Time:	17:54:47	Log-Likelihood:	-1.0511e+06
No. Observations:	187763	AIC:	2.102e+06
Df Residuals:	187754	BIC:	2.102e+06
Df Model:	8		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-5.0257	0.451	-11.140	0.000	-5.910	-4.141
HEIGHT	0.0228	0.021	1.102	0.270	-0.018	0.063
LENGTH	0.4343	0.014	31.636	0.000	0.407	0.461
WIDTH	0.6987	0.023	30.983	0.000	0.654	0.743
SHIP_WEIGHT_POUNDS	0.1703	0.002	105.495	0.000	0.167	0.173
INTERNATIONAL_BINARY	-15.1332	1.017	-14.879	0.000	-17.127	-13.140
is_not_taylor	14.7605	0.891	16.575	0.000	13.015	16.506
DENSITY	5.2760	0.097	54.534	0.000	5.086	5.466
MODE_GROUND_BINARY	-5.3935	0.426	-12.656	0.000	-6.229	-4.558

Omnibus:	631184.505	Durbin-Watson:	1.466
Prob(Omnibus):	0.000	Jarque-Bera (JB):	1284505735032.394
Skew:	-59.378	Prob(JB):	0.00
Kurtosis:	12815.975	Cond. No.	966.

REGRESSION (FREIGHT)

OLS Regression Results

Dep. Variable:	ACCESSORIAL_AMOUNT	R-squared:	0.974
Model:	OLS	Adj. R-squared:	0.974
Method:	Least Squares	F-statistic:	2.127e+06
Date:	Fri, 03 May 2024	Prob (F-statistic):	0.00
Time:	18:04:43	Log-Likelihood:	-2.2124e+06
No. Observations:	288146	AIC:	4.425e+06
Df Residuals:	288140	BIC:	4.425e+06
Df Model:	5		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	28.6846	2.589	11.080	0.000	23.610	33.759
is_not_austin	53.8024	3.018	17.827	0.000	47.887	59.718
not_austin_x_mileage	0.1603	0.002	84.390	0.000	0.157	0.164
IO_CODE	14.6121	0.979	14.928	0.000	12.694	16.531
COST_PER_MILE	0.0010	3.07e-07	3249.740	0.000	0.001	0.001
INTERNATIONAL_BINARY	-111.9561	2.621	-42.713	0.000	-117.093	-106.819

Omnibus:	1200136.769	Durbin-Watson:	0.720
Prob(Omnibus):	0.000	Jarque-Bera (JB):	4252733247455.879
Skew:	116.511	Prob(JB):	0.00
Kurtosis:	18822.154	Cond. No.	1.21e+07

REGRESSION VIF CHECK FOR MULTICOLLINEARITY

Freight

VIF Data:

	Feature	VIF
0	const	7.065255
1	is_not_austin	1.764391
2	not_austin_x_mileage	1.528101
3	IO_CODE	1.061371
4	COST_PER_MILE	1.010430
5	INTERNATIONAL_BINARY	1.797779

Parcel

VIF Data:

	Feature	VIF
0	const	8.963717
1	HEIGHT	2.277567
2	LENGTH	1.977439
3	WIDTH	2.886776
4	SHIP_WEIGHT_POUNDS	1.387446
5	INTERNATIONAL_BINARY	4.910065
6	is_not_taylor	4.505798
7	DENSITY	1.001531
8	MODE_GROUND_BINARY	1.616034

MACHINE LEARNING MODEL

Random Forest

	R^2 Score
EAST	0.439280
WEST	0.994744
MIDWEST	0.992546

Train R^2: 0.953, Test R^2: 0.993
Train MSE: 19590.865, Test MSE: 2240.906