Forecasting International Flows of Returnable Transport Items

By: Patrick Jacobs and Rajdeep Singh

Advisor: Dr. Eva Ponce

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Agenda

Industry Overview

Background

Project Scope
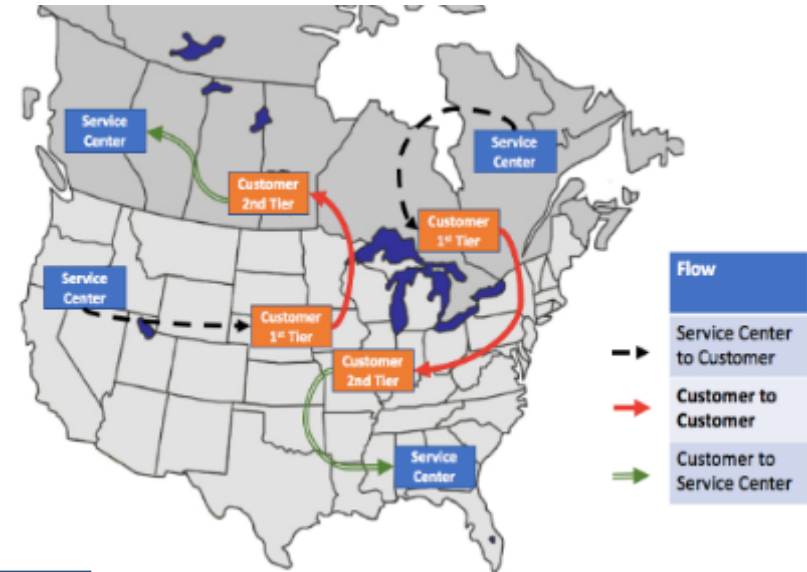
Methodology

Forecasting

Key Takeaways

Future Research Areas

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What is a Returnable Transport Item?

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RTI Leasing Overview

Customer

Full RTI

Empty RTI

Logistics Services Company

Tier II Customer

Full RTI

Empty RTI

Tier N Customer

Flow

- Service Center to Customer
- Customer to Customer
- Customer to Service Center

Service Center

Customer 2nd Tier

Customer 1st Tier

Service Center

Customer 1st Tier

Customer 2nd Tier

Service Center

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RTI Leasing Overview

Flow

- - - ►	Service Center to Customer
—► (red)	Customer to Customer
═► (green)	Customer to Service Center

Service Center
Customer 2nd Tier
Customer 1st Tier
Service Center
Customer 1st Tier
Customer 2nd Tier
Service Center

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Background

International Movements

Background

International Movements

Net International Movements
USA to CA - CA to USA
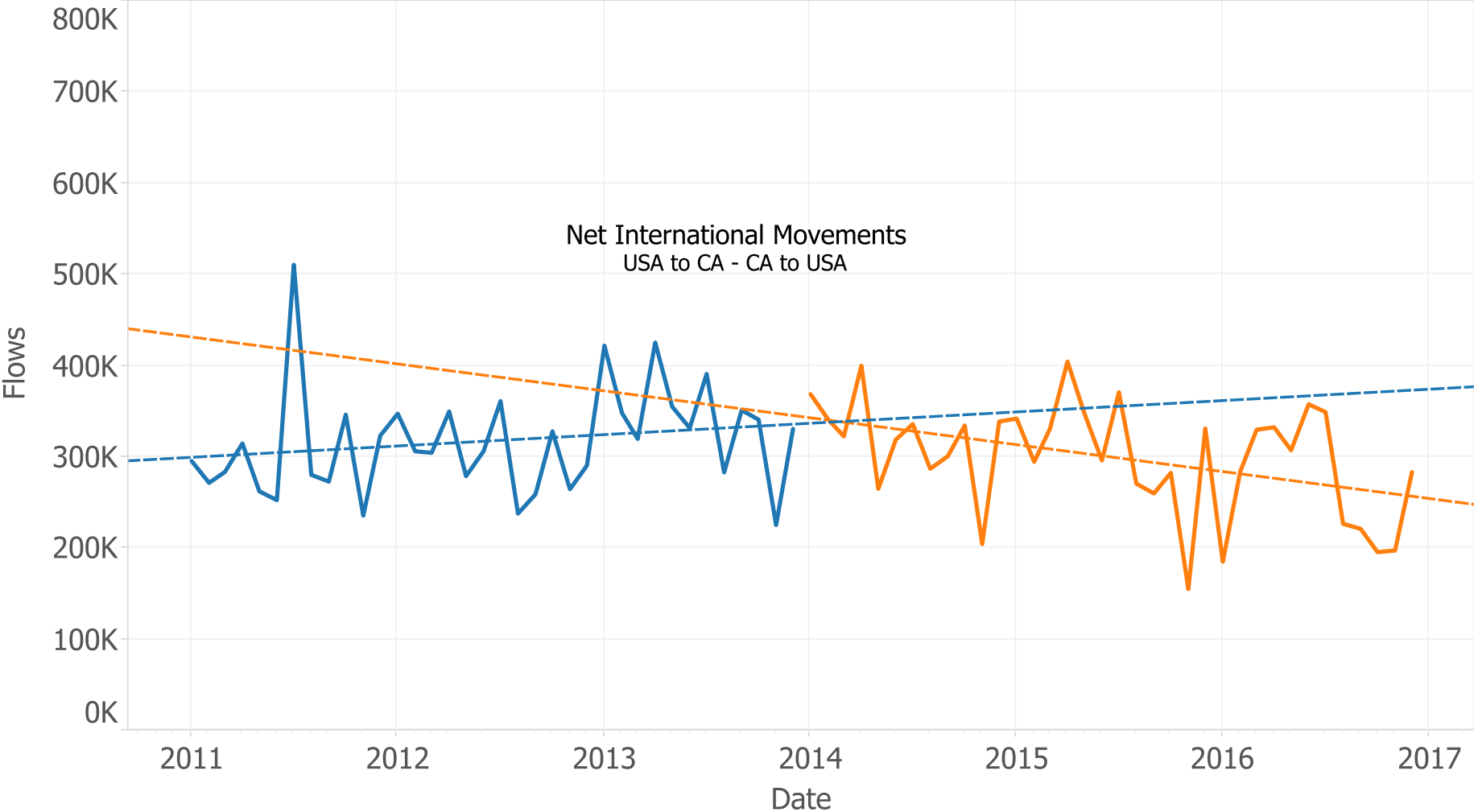
Background

Foreign Exchange Rate CD to USD

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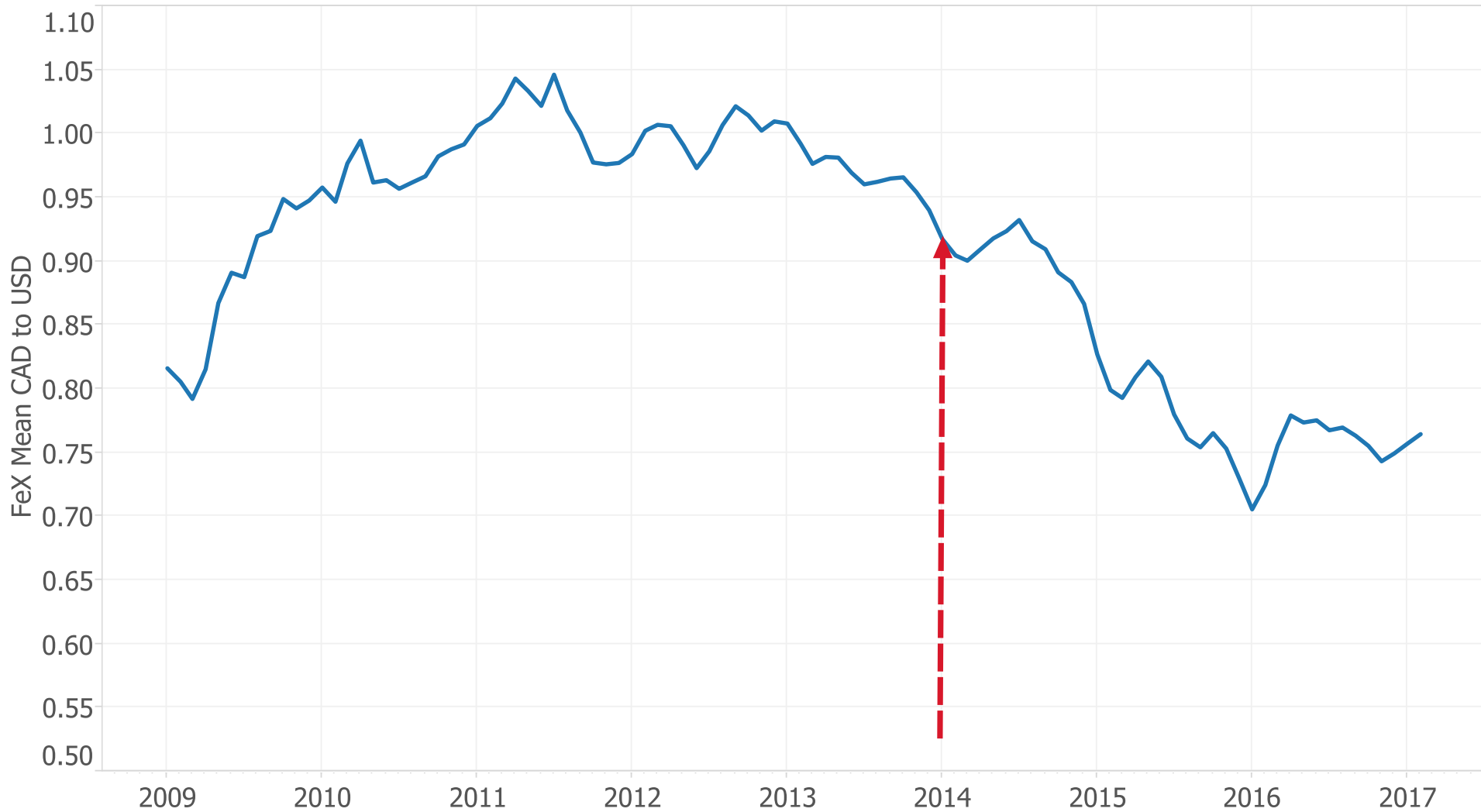
Project Scope

Key Question

- Determine how Foreign Exchange Rates would alter direction of Product Flows between Canada to the US

Project Objectives

- Develop 1-month ahead forecast to **predict International Flows** between Canada and USA

  - Utilizing **macro economic factors as predictive variables**

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Forecasting with Macro Variables

Variables Selection Criteria

- Relevant
- Readily Available

Country	Variable	Aggregation Level
USA & CA	#2 Diesel Prices	Monthly
USA & CA	Foreign Exchange Rate	Monthly
USA	Exports to CA	Monthly
USA	Imports from CA	Monthly
USA	Gold Prices	Monthly
USA & CA	GDP	Quarterly

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Forecasting with Macro Variables

Methodology

- Monthly variable lags range from 1 to 12 months
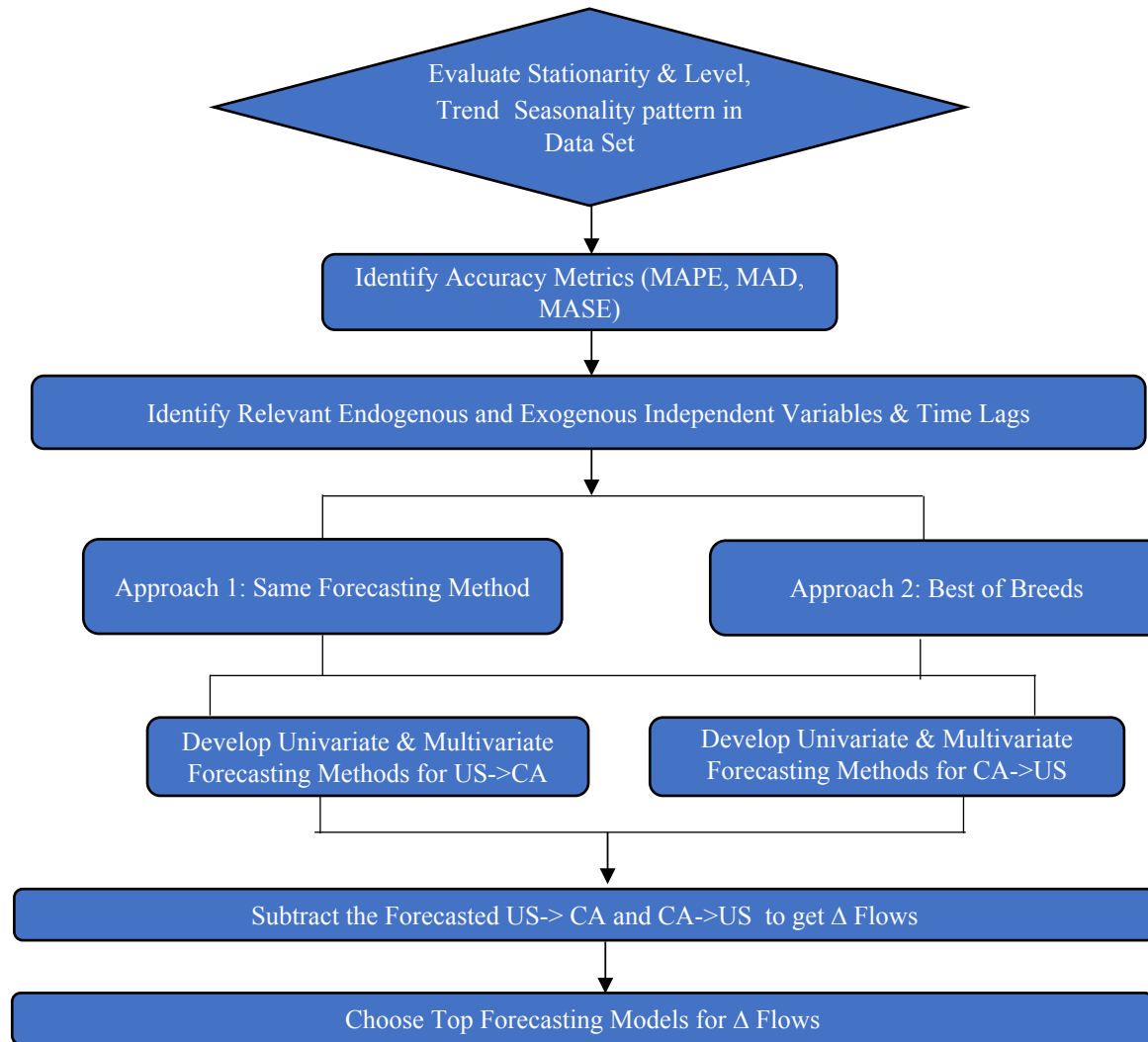- Quarterly variable lags range from 3 to 12 months

Results

Movement	Variable	Lag (Months)	Correlation
CA to USA	US Quarterly GDP	12	0.7197
	Canada Quarterly GDP	12	0.6868
	Average CA to USD FEx	5	-0.6995
USA to CA	--		
Net International	--		

*Correlations where X>.6 or X<-.6

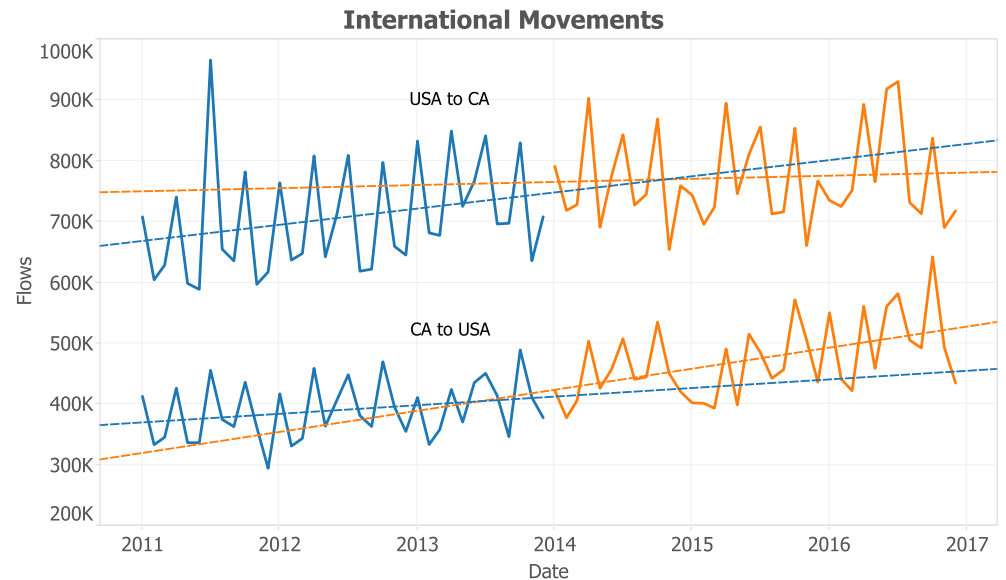MIT Supply Chain
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Forecasting Framework

Evaluate Stationarity & Level, Trend Seasonality pattern in Data Set

↓

Identify Accuracy Metrics (MAPE, MAD, MASE)

↓

Identify Relevant Endogenous and Exogenous Independent Variables & Time Lags

↓

Approach 1: Same Forecasting Method

Approach 2: Best of Breeds

Develop Univariate & Multivariate Forecasting Methods for US->CA

Develop Univariate & Multivariate Forecasting Methods for CA->US

↓

Subtract the Forecasted US-> CA and CA->US to get Δ Flows

↓

Choose Top Forecasting Models for Δ Flows

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Data Analysis
Level, Trend, Seasonality

- **Level** – mean value of Y

- **Trend** – Local mean, period to period difference

- **Seasonality** – Repeating increase or decrease in a given time period
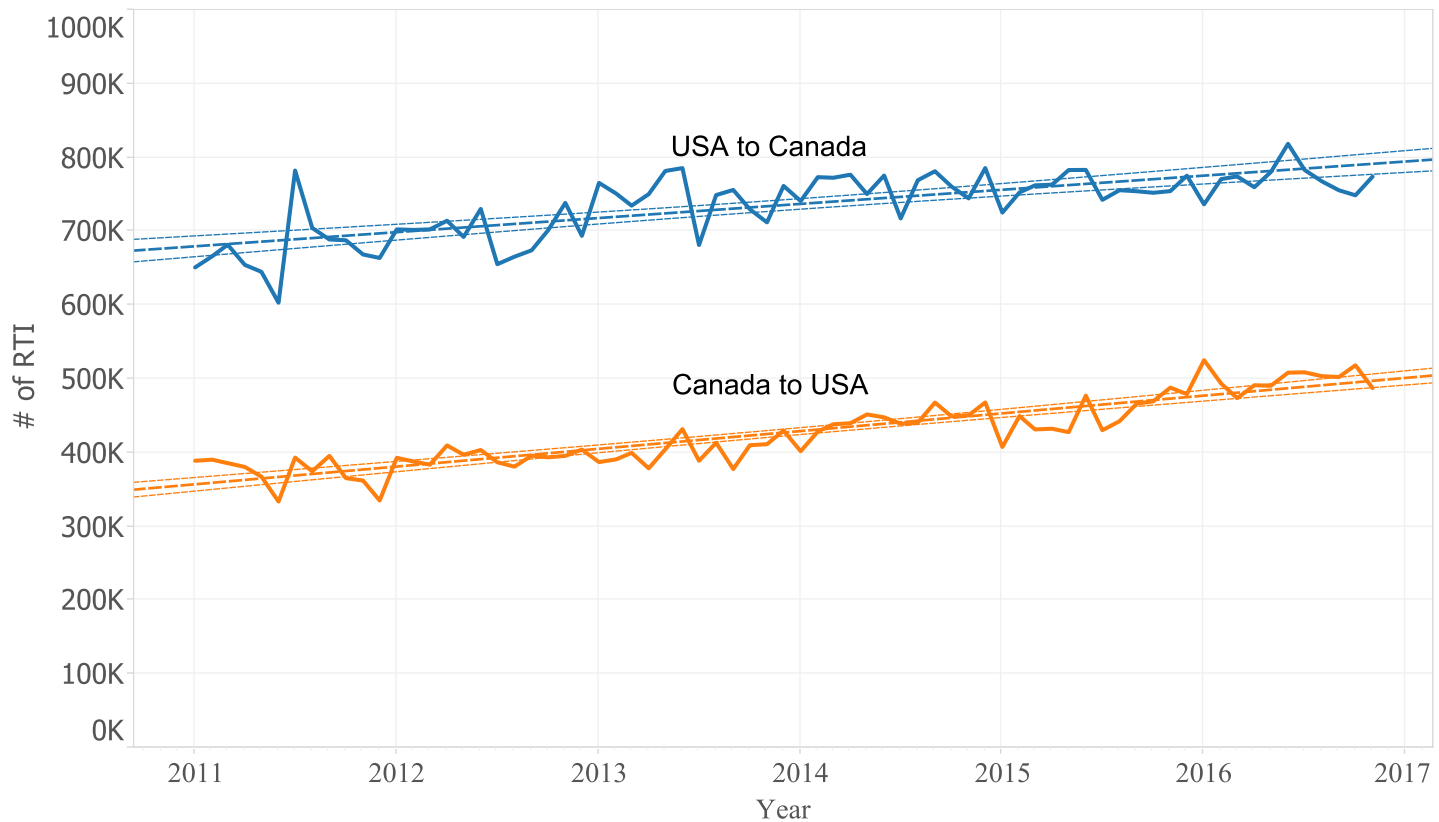
International Movements

USA to CA

CA to USA

Flows

1000K
900K
800K
700K
600K
500K
400K
300K
200K

2011   2012   2013   2014   2015   2016   2017

Date

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Data Analysis

Trend

A slight linear trend exists in the individual flows

Deseasonalized Flows

Data Analysis
Seasonality

Seasonality in Detrended Data
Net International

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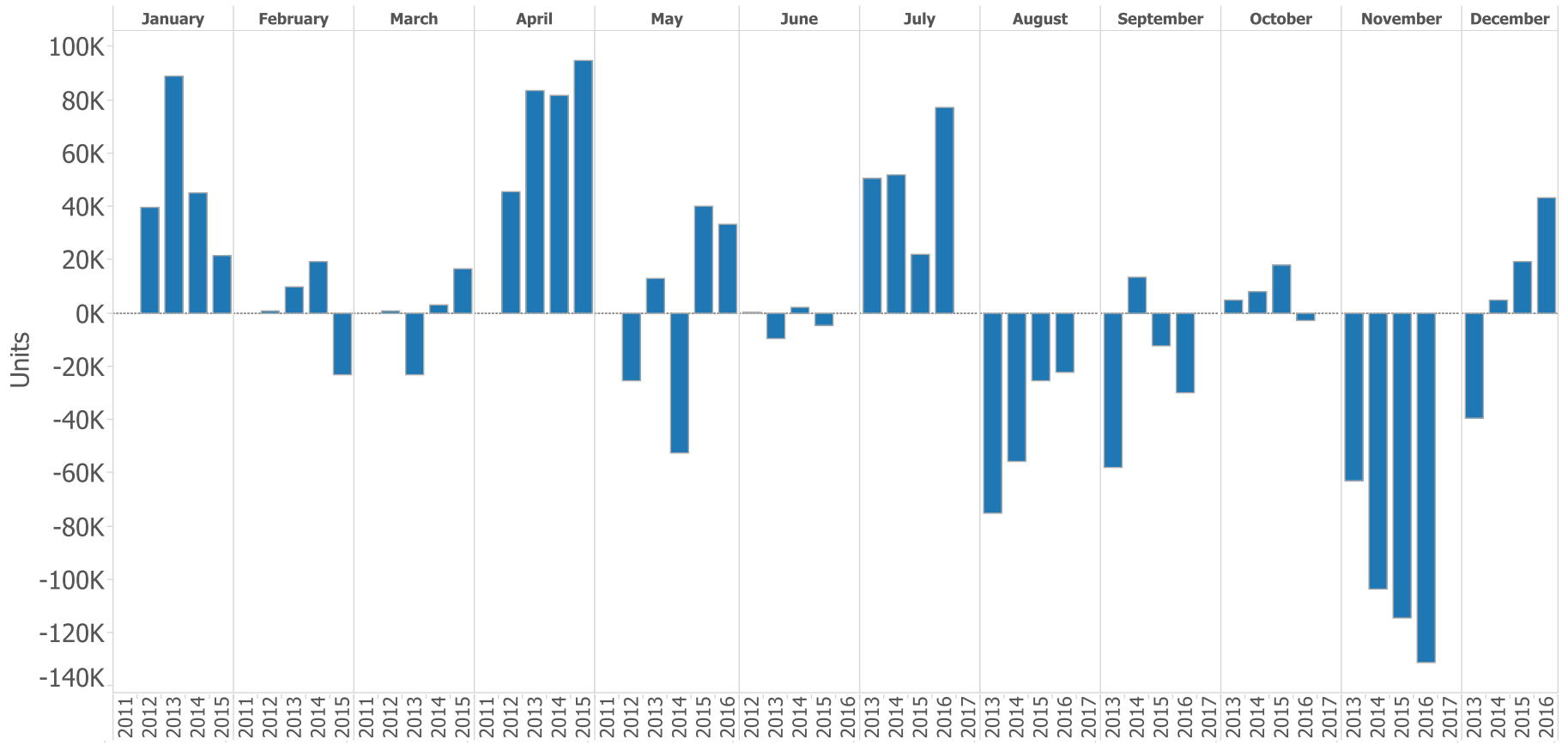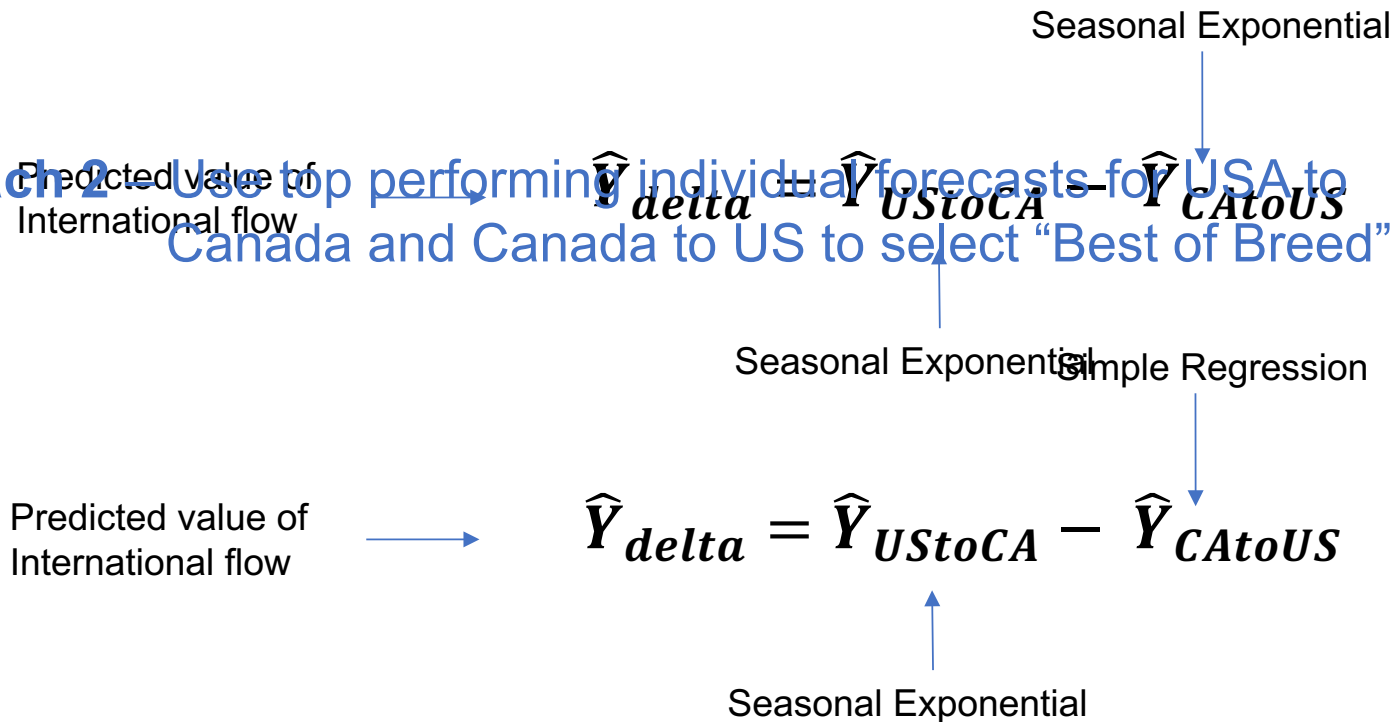
Forecasting Models

- **Stepwise Regression**
    - **Univariate**
    - **Multivariate**
        - **Endogenous**
        - **Exogenous (Macro Economic)**

- **SARIMA** **Seasonal Auto Regressive Integrated Moving Average**

- **Exponential Smoothing - Multiplicative**
    - **Standard**
    - **State Space**

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Forecasting Methodologies

Approach 1 – Use same methodology for USA to Canada & Canada to USA

Approach 2 – Use top performing individual forecasts for USA to Canada and Canada to US to select "Best of Breed"

Seasonal Exponential

Predicted value of
International flow

$$\widehat{Y}_{delta} = \widehat{Y}_{UStoCA} - \widehat{Y}_{CAtoUS}$$

Seasonal Exponential   Simple Regression

Predicted value of
International flow

$$\widehat{Y}_{delta} = \widehat{Y}_{UStoCA} - \widehat{Y}_{CAtoUS}$$

Seasonal Exponential

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Performance Evaluation Metrics

Performance Is Measured by Relative Performance on All Three

$$MAPE = \frac{|Et|}{At}$$

$$MASE = \frac{|Et|}{|Et_{Naive}|}$$

$$MAD = |Et|$$

Mean Absolute
Percent Error

Mean Absolute
Scaled Error

Mean Absolute
Deviation

Error in relation
to actual value

Error in relation
to Naive Ft
error

Absolute Unit
Error

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Performance Evaluation

Metrics

Issue: Imperfect Metrics

Solution: Composite Scores

- **Weighs each metric evenly & compares models performances across all 3 metrics**

Multiplicative: | MAPE Rank | * | MASE Rank | * | MAD Rank |

Mean:
$$\frac{\left(\text{MAPE Rank} + \text{MASE Rank} + \text{MAD Rank} \right)}{3}$$

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Model Selection

Quantitative Selection

Multiplicative Score Rank

Model	Validation			Rank				
	MAPE	MASE	MAD	MAPE	MASE	MAD	Mean Score	Mult Score
SARIMA (0,1,1)(0,1,0) | SARIMA (0,1,1)(1,1,0)	15.3%	3.84	37340	1	28	1	10.00	28
Seasonal Exponential | Simple Regression	15.8%	3.76	40211	2	26		10.67	208
Holt-Winter | Simple Regression	16.8%	3.63	39365	6	21		.67	252
Seasonal Exponential | Seasonal Exponential	16.9%	3.27	40314	7				350
Seasonal Exponential | Endogenous Regression	16.3%	4.09	39895	4				396

Mean Score Rank

Model	Validation			MAPE	M			Mult Score
	MAPE	MASE	MAD					
Seasonal Exponential | Seasonal Exponential	16.9%	3.27	40314	7	1			350
Holt-Winter | Simple Regression	16.8%	3.63	39365	6	21	2		252
SARIMA (0,1,1)(0,1,0) | SARIMA (0,1,1)(1,1,0)	15.3%	3.84	37340	1	28	1	10.00	28
Seasonal Exponential | Simple Regression	15.8%	3.76	40211	2	26	4	10.67	208
Simple Regression M2Y | Simple Regression	16.2%	3.69	41462	3	23	6	10.67	414

Different models selected when using different composite scores

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Model Selection

Qualitative Selection

Model	Mean Score	Mult Score	Update Requirement	Software Dependency
Seasonal Exponential | Seasonal Exponential	7.33	350	1	1
Holt-Winter | Simple Regression	9.67	252	2	1
SARIMA (0,1,1)(0,1,0) | SARIMA (0,1,1)(1,1,0)	10.00	28	1	2
Seasonal Exponential | Simple Regression	10.67	208	2	1
Simple Regression M2Y | Simple Regression	10.67	414	2	1
Seasonal Exponential | Endogenous Regression	13.33	396	3	1
Seasonal Exponential | Simple Regression M3Y	13.67	1015	2	1

Seasonal Exponential | Seasonal Exponential was selected due to quantitative and qualitative performance

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Key Takeaways

1. Macro variables* are not easily tied to micro level data

2. Methodical forecasting identification

3. Time horizons greatly effect time forecast evaluation and performance

Aggregation: Monthly

| Metric	Seasonal Exponential	SARIMA	SE Performance Difference
MAPE	16.79%	15.3%	-8.87%
MASE	3.62	3.83	5.80%
MAD	40492	37340	-7.78%

Aggregation: Yearly

Metric	Seasonal Exponential	SARIMA	SE Performance Difference
MAPE	8.23%	4.68%	-43.07%
MASE	.67	.39	-42.58%
MAD	40492	37340	-43.19%

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Benefits for Reverse Logistic Firms

- Incorporating Seasonality in Inventory Planning

- Strategic Planning for Demand Uncertainty in Reverse Logistics

- Minimize RTI Repositioning Flows ⬇ Transportation Costs

- Improve Balancing of RTI Flows across Network

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Next Steps

Origin California – Destination Province
US Origin States - Spread
Distribution
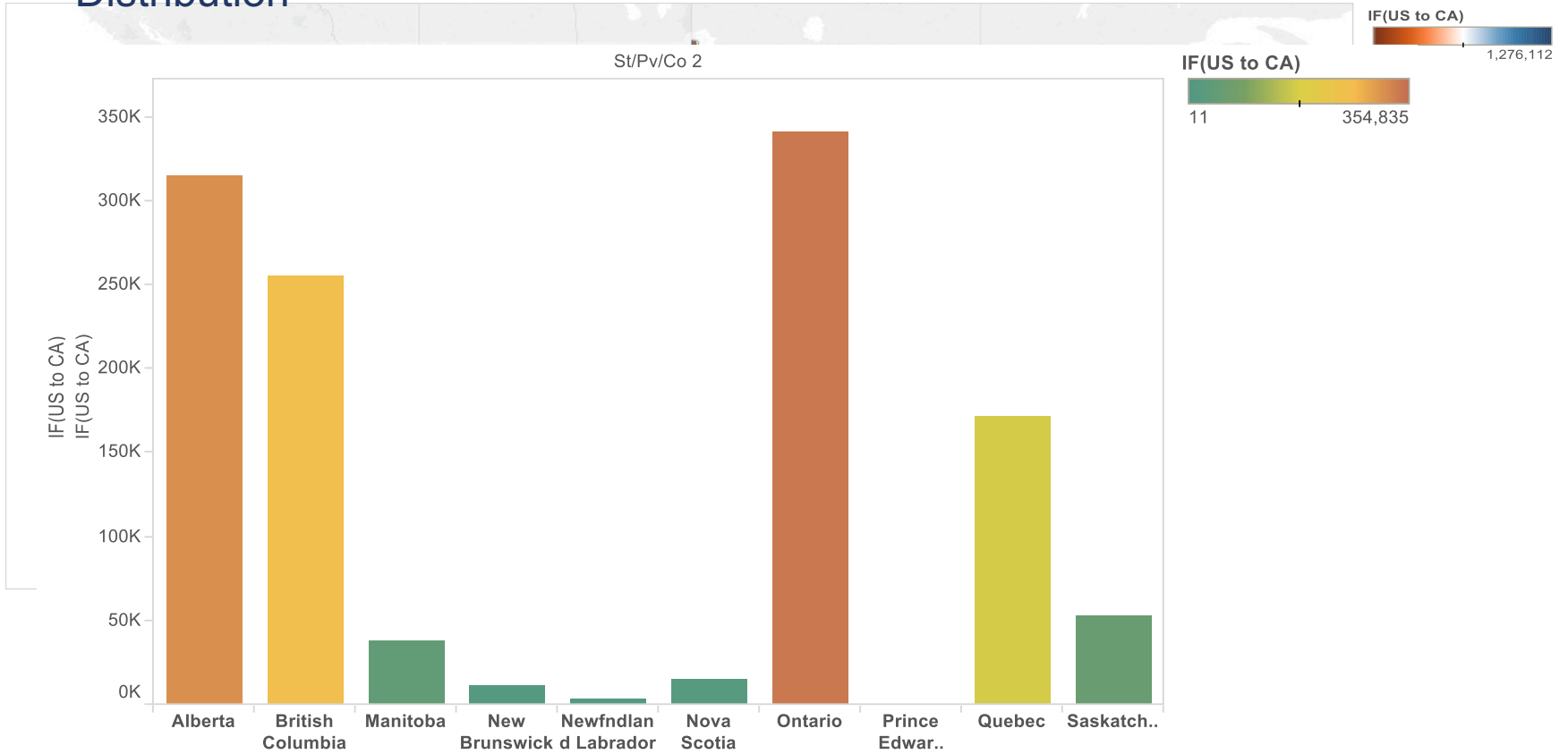
Future Research Areas

1. Forecasting of RTI Flows at more Granular Level

2. Minimize Transportation Costs by Reducing RTI Repositioning
   - Plan Flows to Service Centers : State wide Mix for Destination Flows

3. Tailor Pricing and Leasing Contracts using Historical Cross Border RTI flows

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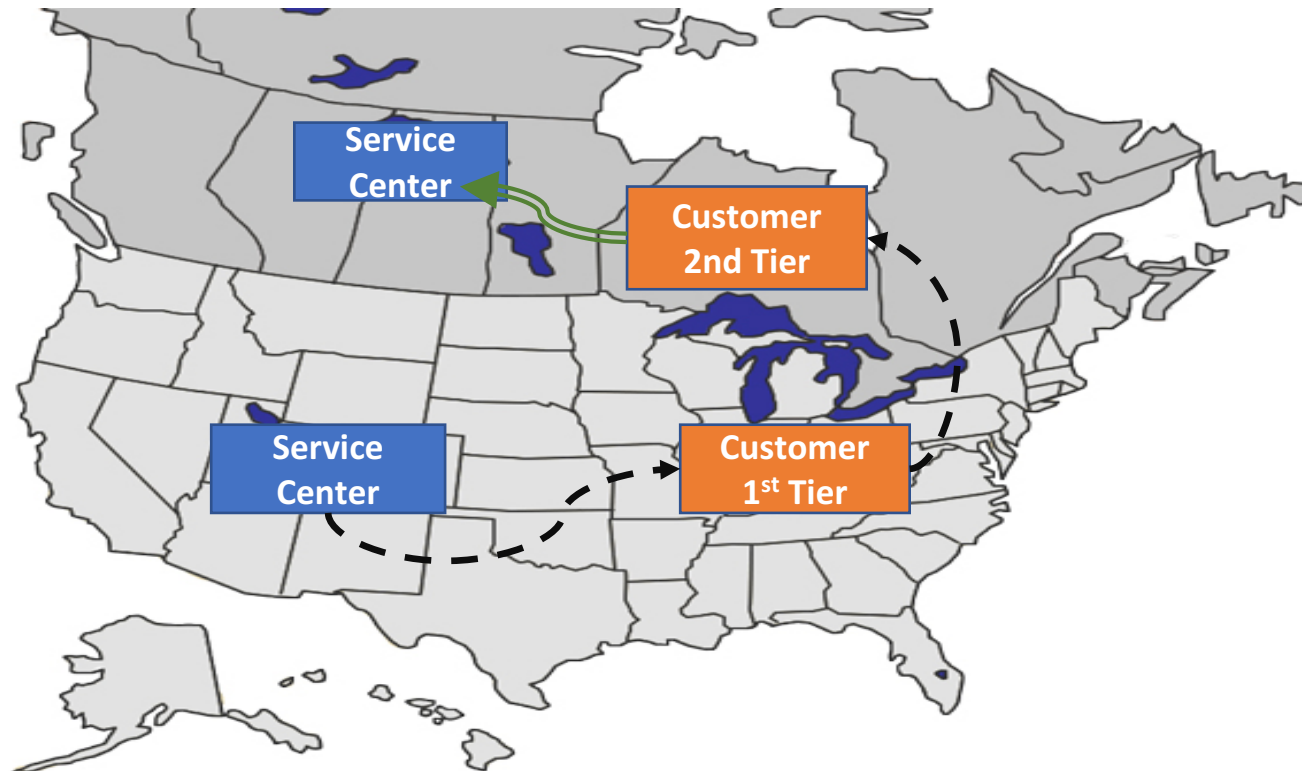
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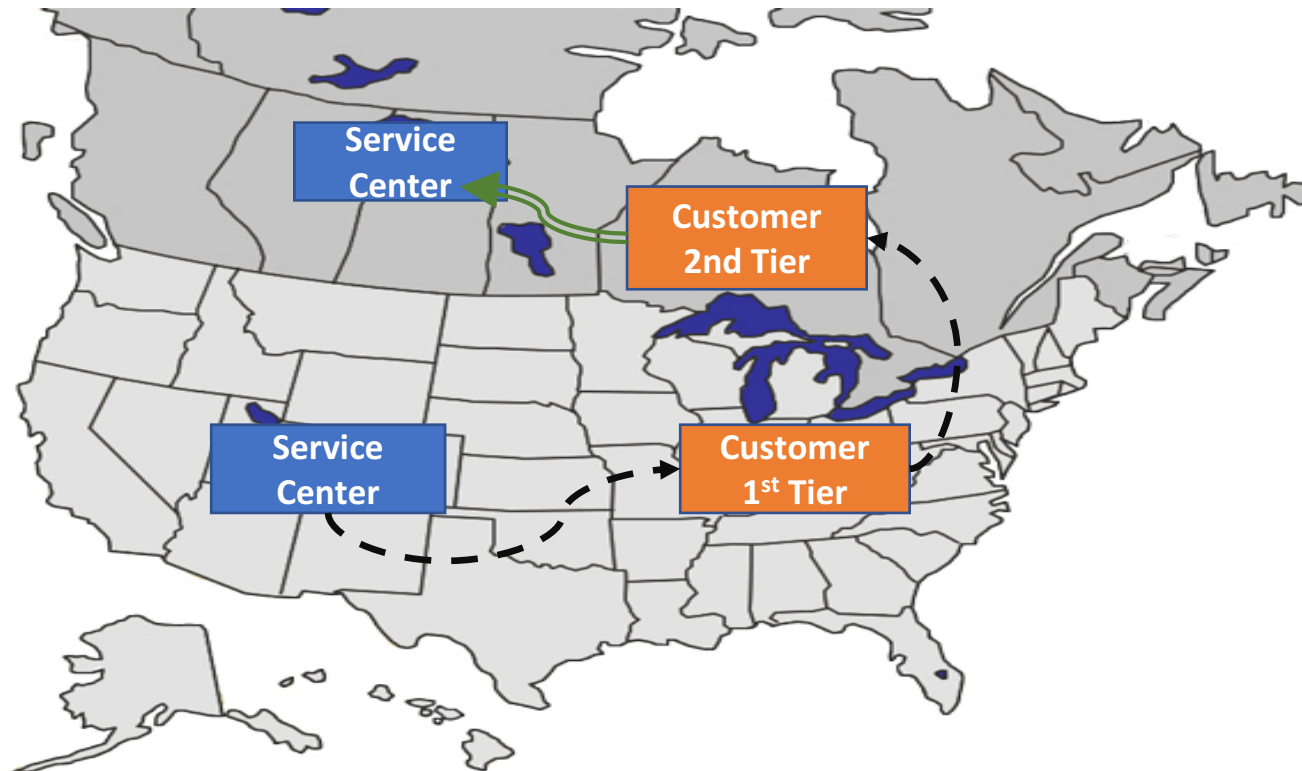
Reference Slides

Data Analysis
Forecastability - CV

	Training	Validation	Total	
US to CA	12.27%	10.77%	16.17%	← Low Variation Within Sets
CA to US	13.17%	12.32%	12.21%	← Low Variation High When — Within Sets — Consistent High Variation
Delta	17.13%	24.58%	19.68%	← High Variation Combined Within Sets – When High Variation Combined When Combined

CA to US is the easiest flow to predict
as the variation is consistent over time

$$CV = \frac{\sigma}{\mu}$$

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Endogenous Variables

- Monthly Network Purchases of Pallets
- Domestic Monthly RTI Issued
- Demand Growth
- RTI Returns to Service Centers

Movement	Variable	Monthly LAG	Correlation
CA to USA	USA - Domestic Issues	3	0.791
	CA - Domestic Issues	3	0.783
	USA Inflows	3	0.771
	CA Inflows	3	0.766
USA to CA	USA Inflows	6	0.785
	USA - Domestic Issues	6	0.743
	USA - Domestic Issues	3	0.672
	CA Inflows	6	0.659
Net International	--	--	

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