Transportation Cost & Tariff Optimization in the Specialty Tire and Wheels Industry

Capstone Presentation

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MIT Supply Chain MANAGEMENT

Company Overview

The Carlstar Group

- Leader in the specialty tire and wheel industry
- Global footprint in North America, Europe, Asia
- Headquartered in Franklin, TN

Carlstar Group Brands

CARLISLE · CRAGAR · BLACK ROCK · UNIQUE · ITP · MARASTAR

Products

Tires

Wheels

Flat-free

Tubes

Distribution Channels

- OEM
- Aftermarket

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Current Events

The New York Times

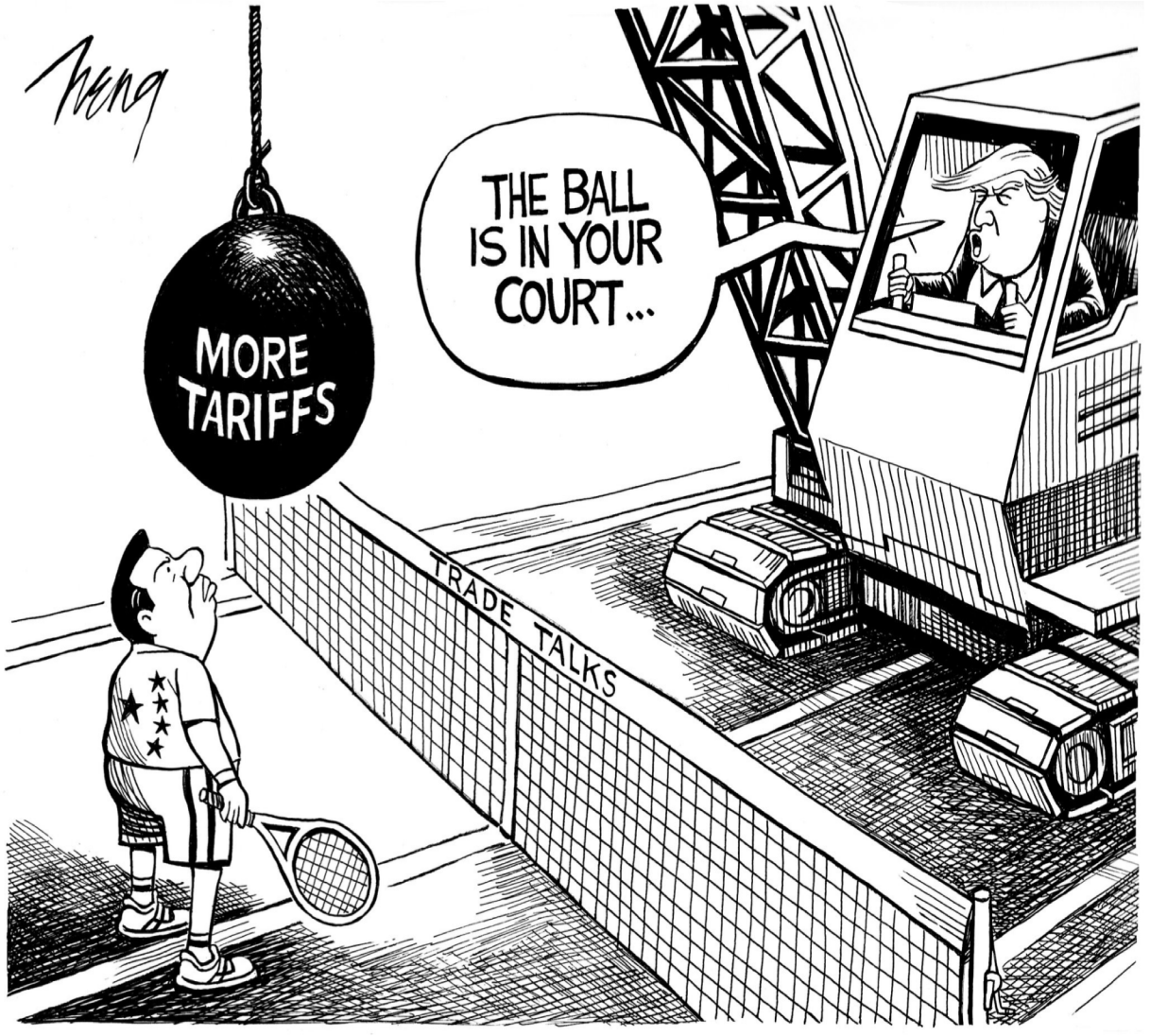
All Pain, No Glory in Trad

No clear winner as the world's two largest out.

By Heng

Heng Kim Song is an editorial cartoonist.

May 19, 2019



A China Ocean Shipping Company container is lifted up at Hutchison International container port in

Problem Statement

With the dramatic changes in both US tariffs and transportation costs, the Carlstar Group is redefining how they plan, store, ship, and order inventory. How should the company evaluate changing transportation routes and methods for cost optimization?

Agenda

- Opportunity & Objective
- Methodology
- Scenarios
- Model Results
- Key Takeaways

Opportunity and Objective

Products flow along multiple paths from manufacturing to customer:

- 4 Manufacturing Sites (3 US, 1 China)
- 11 Distribution Centers (8 US, 2 Canada, 1 Europe)
- Dozens of shipping ports
- Hundreds of end customer demand points
- Differing shipping methods (FEU/TEU, FTL/LTL, etc.)

Flows impacted by changing tariff and transportation rates

Research Objective

- Further optimize how Carlstar ships products to minimize costs
- Create a model that can to enhance Carlstar's transportation decision-making
- Identify potential cost savings from implementing change

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Data Segmentation and Analysis

Product flows were segmented by five primary market segments:

Agriculture & Construction (AGC)

Powersports (POW)

High Speed Trailers (HST)

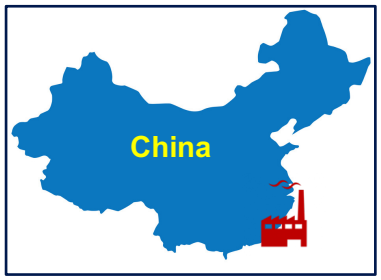
Outdoor Power Equipment (OPE)

Automotive & Styled Wheels (STW)

In-scope analysis includes:

- Four primary manufacturing locations: Aiken, SC; Jackson, TN; Clinton, TN and Meizhou, China (~86% of total products manufactured)
- Finished goods -- excludes assembly
- 2018 US and Canada demand -- excludes Europe
- Minimum customer demand (by 3-digit ZIP) of at least 12 Full Truck Load (FTL) equivalents received per year (~89% of demand)

In-Scope Supply Chain Network



Legend

- Manufacturing (4)
- Distribution Center (7*)
- Port (9)
- Customer (192)

*Three add'l DCs at US MFG sites

Model Inputs

Indices:
- i: MFG index (3 US, 1 China)
- j: DC index (5 US, 2 Canada)
- k: customers (192 modeled)
- m: Market Segment (AGC, HSP, OPE, POW, STW)

Transportation:
r: MFG to DC: Actuals $ used
t: MFG to Customer: Actuals $ for ocean freight, $/mile for Drayage, in FTL/FCL units
s: DC to Cust: $/mile

Tariffs:
b: 10% unit cost $\forall\ x\ where\ i = China,$ j $= US$ for all MFG (China) to DC (US)
c: 10% unit cost $\forall\ z\ where\ i = China,$ j $= US$ for all MFG (China) to Customer(US)

Handling cost:
- h: 10% Unit cost for all DC to Cust by DC

Parameter:
- d: demand by customer, market segment, MFG origin

Variables:
- **x:** product shipped MFG to DC
- **y**: product shipped DC to customer (optimized)
- **z:** product shipped MFG to customer, Integer (optimized)

Model Formulation

Objective function: **Minimize** total transportation, tariff, and handling costs

$$\sum_m \sum_i \sum_j r_{ijkm} x_{ijkm} + \sum_m \sum_j \sum_k s_{kjm} y_{jkm} + \sum_m \sum_i \sum_k t_{ikm} z_{ikm} +$$

Transport

Tariff

$$\sum_i \sum_j \sum_m b_{ijm} * x_{ijm} + \sum_i \sum_k \sum_m c_{ikm} * x_{ikm} +$$

$$\sum_m \sum_j h_{jm} * y_{jkm}$$

Holding Cost

Constraints:

$$\sum_i z_{ikm} + \sum_j y_{jkm} \geq d_{km}$$

Shipments from MFG and DC to customer must be greater than demand

$$\sum_i x_{ijm} \geq \sum_k y_{jkm}$$

DC inbound shipments must be greater than outbound

$x, y, z \geq 0$, z: integer

All product flows greater than 0

MILP modeled in Excel with What's*Best!* Add-in

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Model Scenarios

Model run for each scenario. Sensitivity analysis required multiple runs for each scenario

Baseline

Optimal

Tariff Sensitivity

Transportation Cost Sensitivity

Demand Sensitivity

Handling Cost Sensitivity

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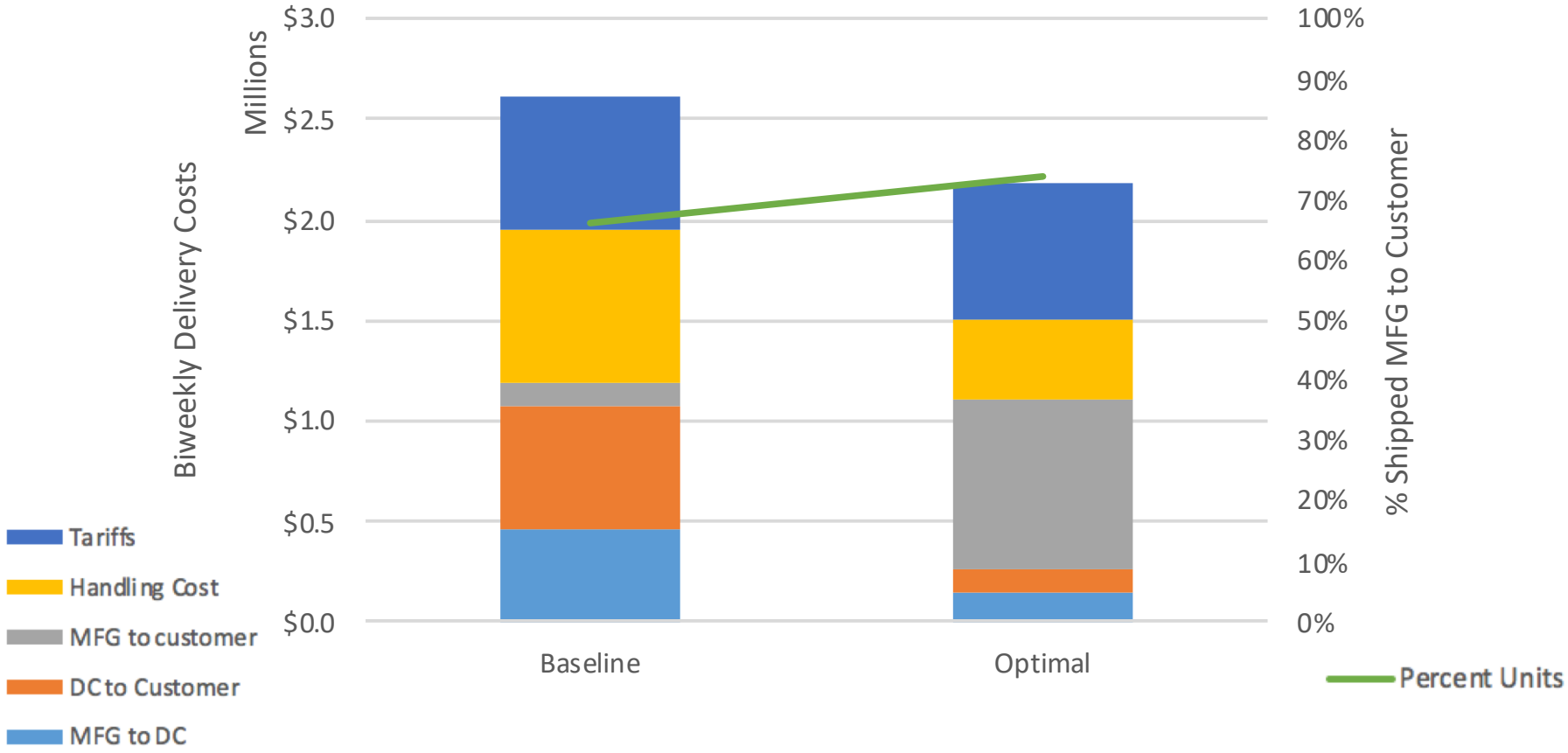
Baseline vs Optimal Solution

Optimal solution reduces transportation costs by 17% over current transportation flows

(based on model projected costs)

Increases direct to customer unit shipments



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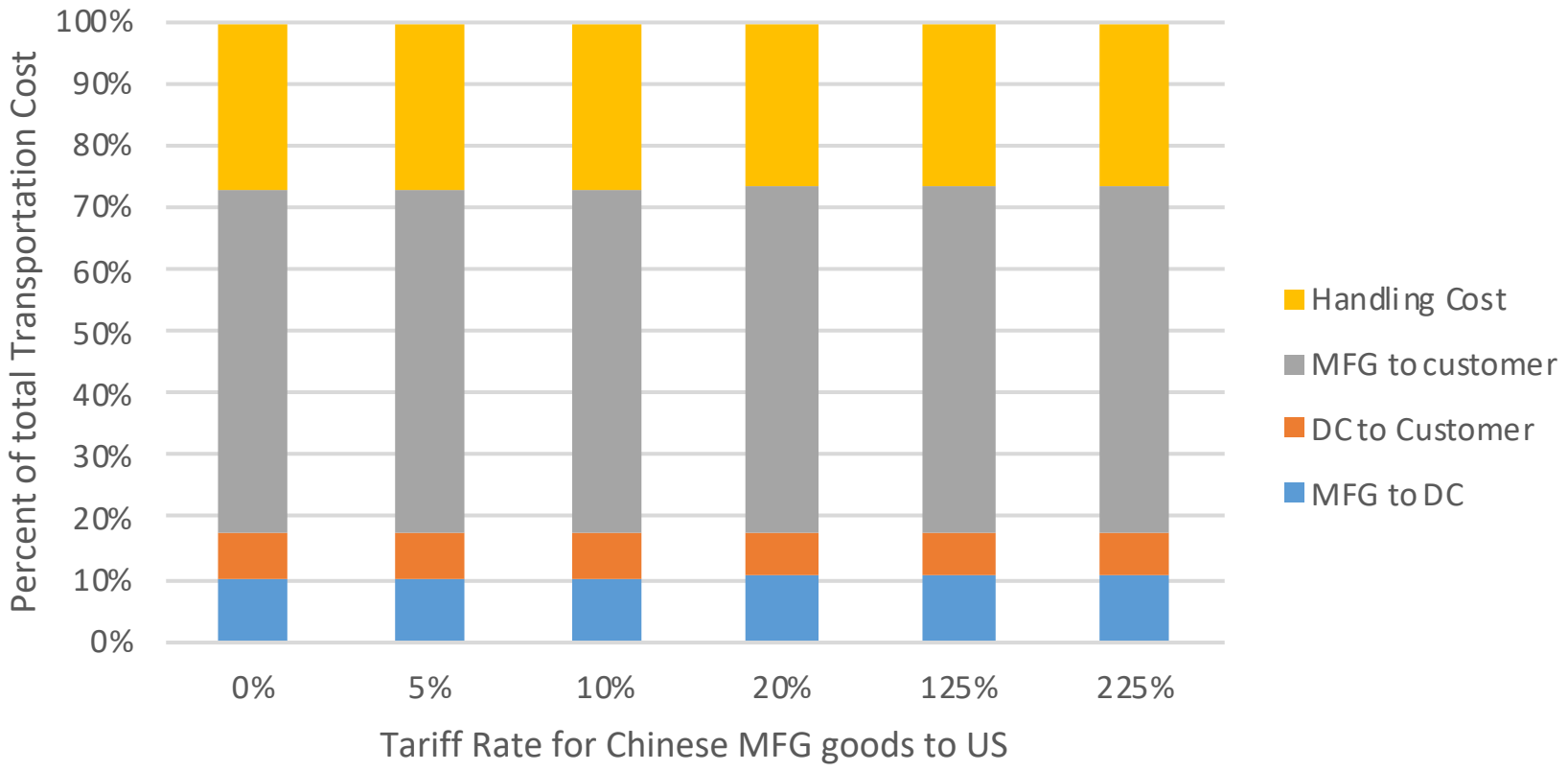
Tariff Sensitivity

10% tariff rates: Chinese manufactured goods went through US based DCs

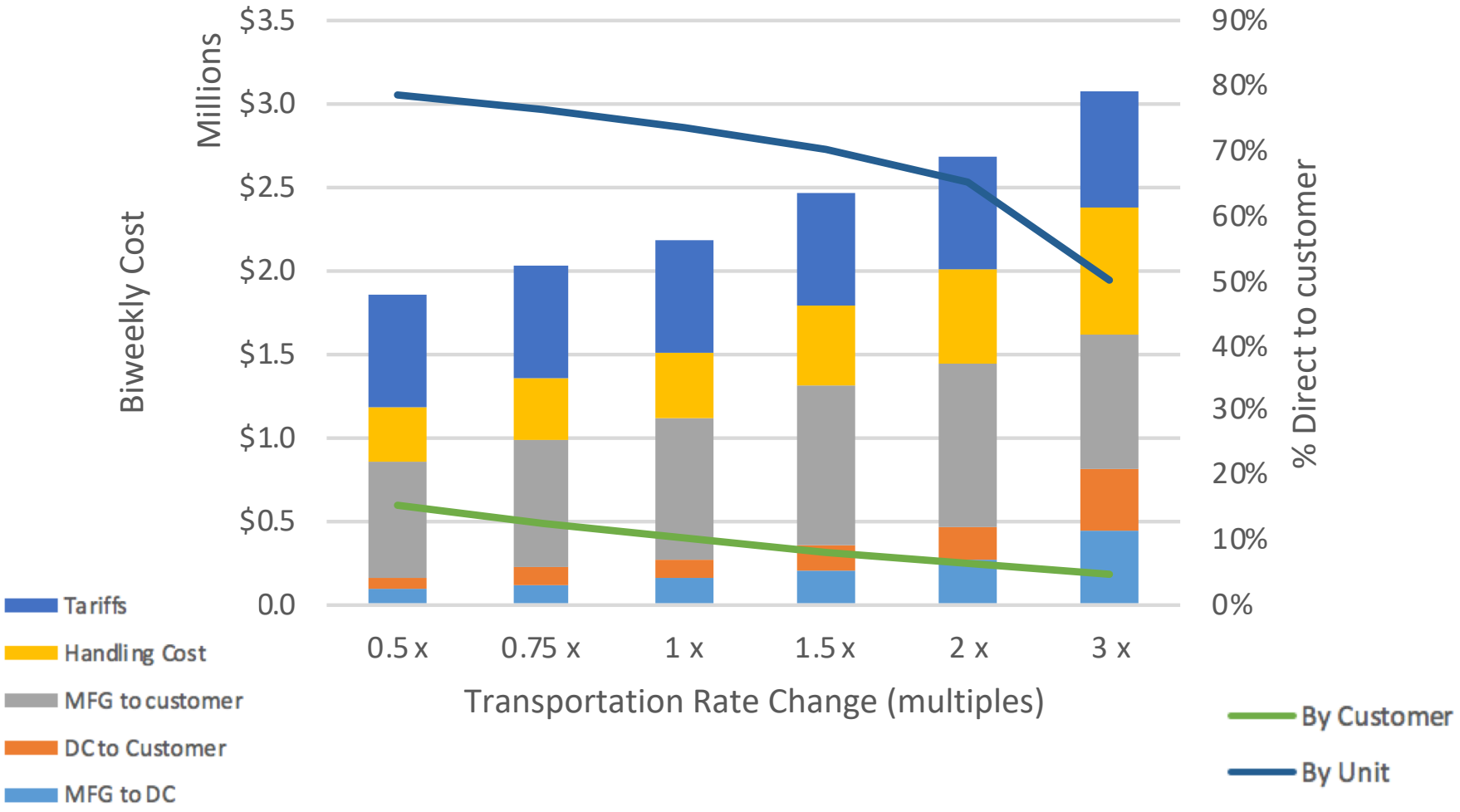
15% tariff rates: Chinese manufactured goods went through Canadian DCs

13% of Canadian customers received direct-to-customer shipments (80% by units)



Transportation Sensitivity

Changes in optimal flows were not significant as transportation rates changed

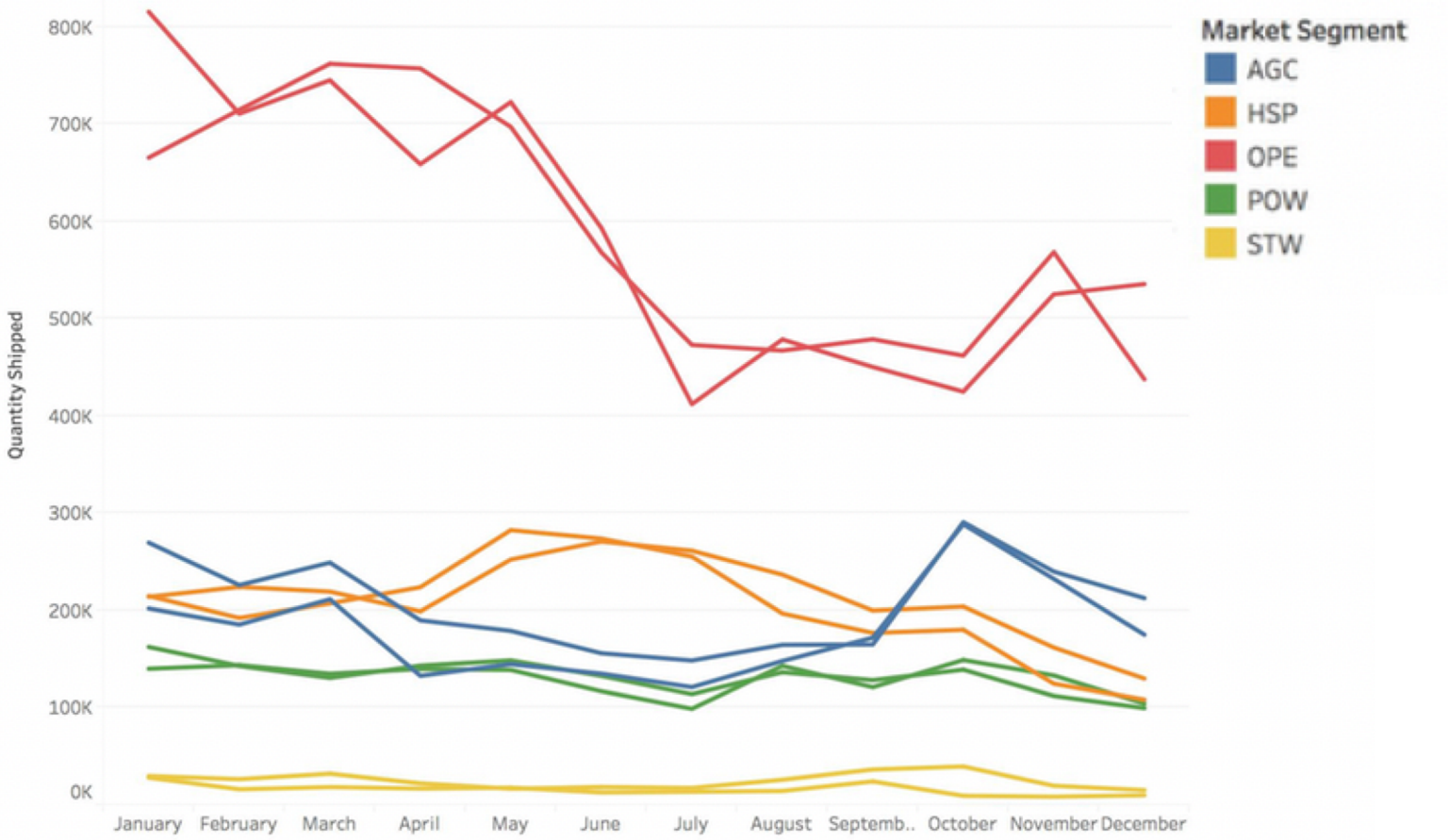


Demand Sensitivity

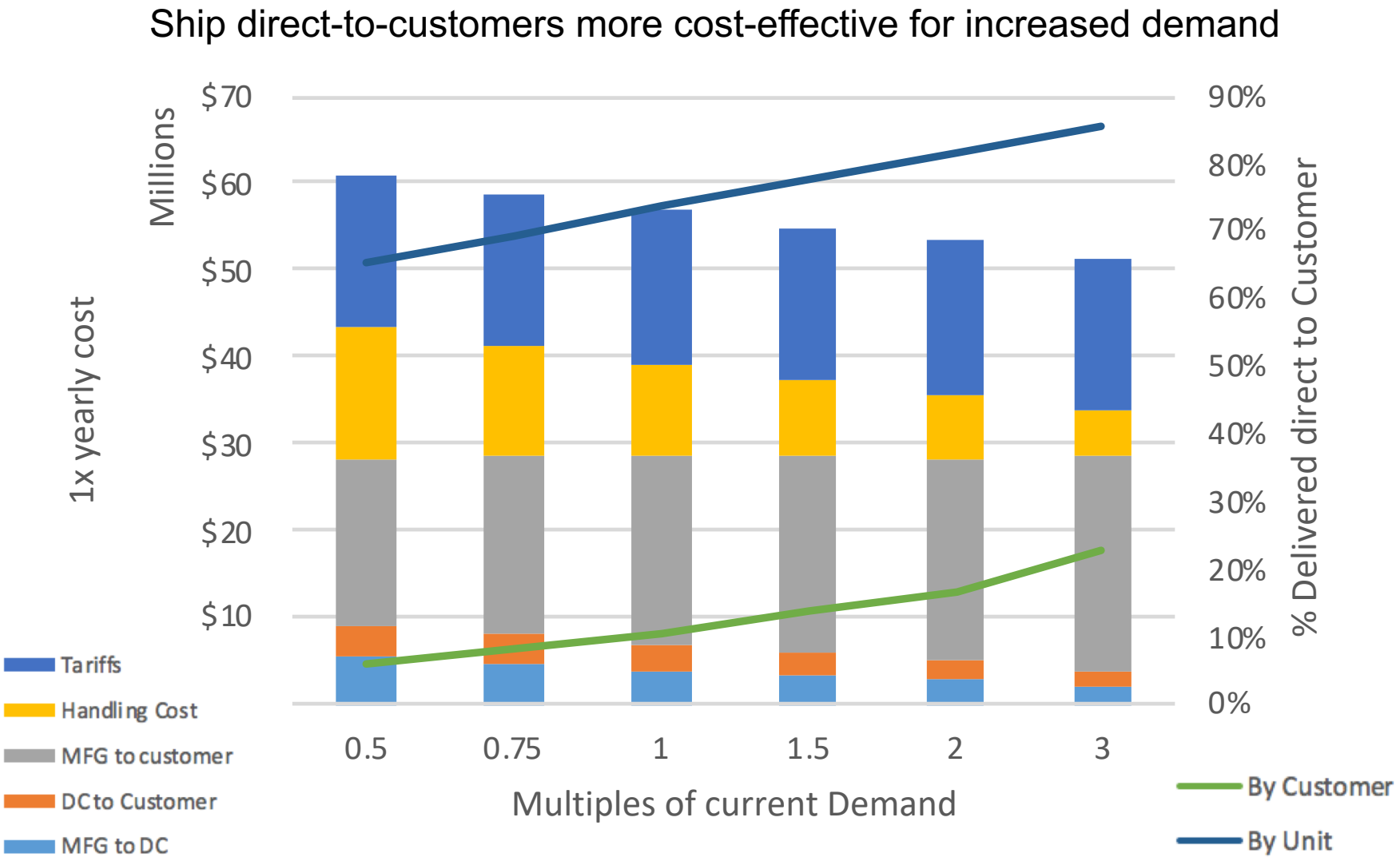
Significant seasonality only seen with OPE Market Segment

Increased OPE Demand did not materially influence optimal flow

Optimal solution is robust and does not need to change by season



Demand Sensitivity



Handling Cost Sensitivity

Optimal solution was significantly more efficient when handling costs were removed

As handling costs increased, switch to direct-to-customer increased significantly

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Key Takeaways

Savings of 17% possible with optimized routing

Optimal transportation flows are resilient to small outside changes

Shipping direct to customer can be cost-effective even at low-levels of utilization

Handling costs had strongest influence on optimal transportation flows

Tariffs of 15% or greater cause switch to direct-to-Canada DC shipments, but did not increase direct to customer shipments

Next Round

Evaluate direct-to-customer shipments for all top 10% of customers by demand

Prepare for China MFG to Canadian DC shipments

Investigate true handling costs at each DC/market segment and re-run model for optimal solution

Future Opportunities for Research

- Alternative Manufacturing Locations
  - Model constrained to 4 primary manufacturing locations
  - Reliance in Chinese manufacturing exposes company to tariff volatility
  - Investigate new manufacturing locations or a shift to more US production

- Broaden Data Scope
  - Granular analysis at the stock-keeping unit level or specific customer level
  - Investigate excluded elements (i.e. assembly, parcel shipments, customers receiving less than 12 FTLs, European demand, etc.)

- Supply Chain Optimization Software
  - Various enterprise technologies exist and could augment model

Question?

Contact Information

- Not sure if we need this or not, so placing a reminder…

Methodology

Objective-Minimize total transportation, tariff, and handling costs for US and Canadian Demand

$$\sum_m \sum_i \sum_j r_{ijkm} x_{ijkm} + \sum_m \sum_j \sum_k s_{kjm} y_{jkm} + \sum_m \sum_i \sum_k t_{ikm} z_{ikm} +$$ Transport $

Tariff $ $$\sum_i \sum_k \sum_m a_{ikm} * y_{ikm} + \sum_i \sum_j \sum_m b_{ijm} * x_{ijm} + \sum_i \sum_k \sum_m c_{ikm} * x_{ikm} +$$

$$\sum_m \sum_j h_{jm} * y_{jkm}$$ Holding Cost $

Variables:

- **x:** product shipped MFG to DC
- **y**: product shipped DC to customer
- **z:** product shipped MFG to customer

Parameters:

- **r:** Transport cost MFG to DC
- **s**: Transport cost DC to customer
- **t:** transport cost MFG to customer
- **a,b,c**: import costs
- **h**: Handling costs

Constraints:

$$\sum_i z_{ikm} + \sum_j y_{jkm} \geq d_{km}$$

Shipments from MFG and DC to customer must be greater than demand

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