Transportation Cost and Tariff Optimization in the Specialty Tire and Wheel Industry

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Topic Areas: Transportation, Optimization

Summary: This capstone evaluated the impact transportation and tariff rate fluctuations have on the optimal transportation network flow. To determine the optimal flow for The Carlstar Group, a global leader in the specialty tire and wheel industry, a mixed integer linear programming model was developed. Results indicate that 17% savings on distribution costs can be achieved by increasing the number of direct to customer shipments. Further, optimal network flows were fairly resilient to fluctuations in transportation and tariff rates.

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Prior to MIT, Brian served as an officer in the United States Navy and worked in program management at John Hancock Financial Services. He received a Bachelor of Arts in Political Science from the University of Notre Dame and a Master of International Business from The Fletcher School at Tufts University.

KEY INSIGHTS

1. **Factors within the company's control, primarily handling costs, drove optimal transportation flows. Fluctuations in tariffs and transportation rates had a much smaller effect.**
2. **For the sponsor company, the optimal transportation network design is resilient and does not need to be adjusted for small external changes.**
3. **Shipping direct from the manufacturer to customer is cost-effective even at lower levels of utilization.**

Introduction

In order to be competitive in the market, a firm must maintain a disciplined approach to optimizing its cost structure. Components of that cost structure, such as tariffs and transportation rates, can be highly volatile and subject a firm to an increased risk of sub-optimal financial performance. To address this volatility and risk, firms need to be prepared to adjust operations and make alternative business decisions given the changing environment.

The Carlstar Group partnered with our team at MIT to assess how it currently ships its products from the manufacturing origin to the end customer. Given the recent volatility in tariff rates, Carlstar believed that there was an opportunity to optimize transportation-related decision-making and generate potential cost savings. Carlstar provided historical transportation data as well as data detailing orders to its suppliers. After reviewing the data, we believed that an opportunity existed to optimize how products flow from the manufacturer to the end customer. As such, our research focused on developing an Excel-based model that would enhance transportation-related decision-making and optimize total costs.

The objective of this project was to create a tool that would enable Carlstar to make more informed decisions about how it shipped its products from the manufacturer to the end customer. The tool would incorporate different cost and tariff rates and provide Carlstar with the optimal product flows. Using the data provided, we segmented the company's products by market segment and built a model that selected the optimal product flow and minimized costs.

Methodology and Data

The objective of this project is to create a network optimization model, using a Mixed Integer Linear Program (MILP) approach. The model was utilized to support the sensitivity analysis and can continue to be used by the company to identify the most cost-effective transportation flows as rates change.

We first established an understanding of Carlstar's current global network footprint and how its products flowed from manufacturing origin to the end customer destination. To assist with model development, Carlstar provided data on the following: manufacturing, ocean freight, drayage, shipments to DCs, and shipments from DCs to end customers. Given the complexity of Carlstar's product lines, analysis segmented products by market: Agriculture and Construction, High Speed Trailer, Outdoor Power Equipment, Powersports, and Automotive Styled Wheels.

In-scope data included demand for US and Canadian customers only, aggregated by 3-digit ZIP code, whose yearly demand for all US- and China-produced finished goods exceeded 12 Full Truck Loads (FTLs). Excluded from the dataset were customers who receive less than 12 FTLs a year (~10% of total demand); products procured from other countries outside of US and China; and products requiring assembly. These elements were removed to align the data with the project scope and minimize model complexity while still maintaining sufficient data to ensure the model's validity. The model included 4 manufacturing plants (3 US, 1 China), 7 distribution centers (5 US, 2 Canada), 9 ports (6 US, 3 Canada) and 192 customers (178 US, 14 Canada.) US and Canada demand included in the model is displayed in Figure 1.

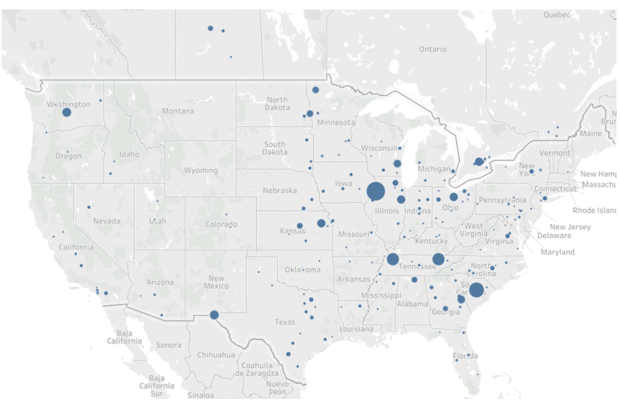

Figure 1: US and Canada Demand (>12 FTL/yr)

Using this dataset, we developed an Excel-based MILP model to identify the optimal product flow for Carlstar's products, classified by market segment. The
objective function of the model seeks to minimize the total cost for all transportation, tariff and handling costs. Transportation costs included ocean freight, drayage, and ground transportation. The model variables were the potential flow paths the product could take from manufacturing origin to each customer: from manufacturer direct to customer or manufacturer to DC to customer. A demand constraint ensures that demand is met for each customer. A transshipment constraint required that for each product delivered from a DC, sufficient product was also sent to that DC from the applicable manufacturing facilities. All products were modeled by market segment. Lastly, in order to support all the variables and constraints required for the model, the Excel optimization add-in called What'sBest was used. This add-in allowed the total variable count to exceed Excel Solver's 200-variable limit.

Results

The optimal product flow was analyzed after running the model under six different scenarios:

1. Baseline
2. Optimal Solution
3. Tariffs Sensitivity
4. Transportation Cost Sensitivity
5. Demand Sensitivity
6. Handling Cost Sensitivity

Model runs provided insight into the system's sensitivity to various changes across tariffs, transportation rates, demand fluctuations and handling costs variations. In Figure 2, the optimal scenario compared to the baseline showed that savings could be generated by shipping direct from the manufacturer to the customer. The distribution of costs between the two solutions

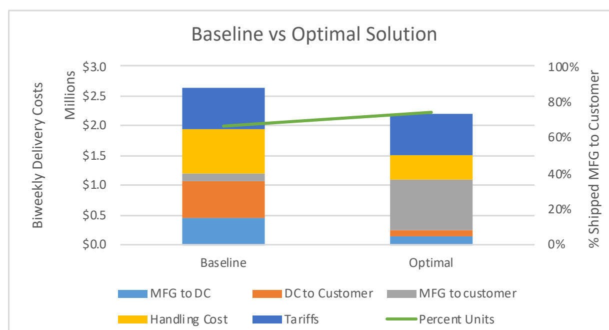

Figure 2: Optimal Scenario vs. Baseline

Model output results also showed that the optimal product flow was more reactive to internal factors rather than external factors. For example, changes in tariffs and transportation rates did not have as significant an effect on the optimal transportation flows compared to changes in handling cost or demand. This implies that the greatest influences on the optimal transportation routings are influenced by Carlstar's own actions and policies.

Percent delta from Optimal Solution		Baseline	Optimal	20% Tariffs	Transport 1.5x	Demand 1.5x	Handling 20%
Freight Cost	MFG to DC	200%	0%	5%	34%	-13%	-19%
	DC to Customer	472%	0%	-1%	29%	-16%	-22%
	MFG to customer	-87%	0%	0%	14%	3%	23%
Handling Cost		88%	0%	0%	18%	-17%	50%
Tariffs		-1%	0%	98%	0%	0%	0%
	TOTAL	20%	0%	31%	13%	-4%	16%
% Units	Direct to Customer	66%	74%	74%	70%	78%	80%
	DC to Customer	34%	26%	26%	30%	22%	20%

Table 1 Scenario Results

Conclusion

Through multiple runs of the MILP model, we were able to gain a better appreciation of Carlstar's supply chain resilience when confronted with tariff and transportation variability. The current transportation flow appears adequate, although there is room to drive greater cost savings and efficiency. As shipping direct from the manufacturer to the customers is often the most cost-effective solution, it would be mutually beneficial for Carlstar to work with their top 10% of customers in terms of volume and coordinate direct shipments.

While the optimal solution was not as reactive to changes in tariffs, should tariffs climb to 15%, it may become more cost effective to ship goods manufactured in China directly to Canada. Utilization rate of these containers would have to be analyzed, however.

Significant changes in the optimal transportation flow in response to transportation rate fluctuations were not observed. This indicates that there is more resilience in the transportation network design and does not require frequent adjustments once an optimal flow is identified.

Transportation flows were also not very reactive to fluctuations in demand, so the optimal flow would serve Carlstar well for both their regular and high seasons. As demand increased, however, it did become more cost effective to ship direct to the customer.

The model was very reactive to changes in the handling costs. The optimal solution without handling costs utilized a transportation structure that was much more efficient than the flows that had to consider handling costs. It is recommended that Carlstar investigate the handling costs at each location and for each market segment. The newly calculated handling costs could then be entered into the model to gain greater clarity into the most cost-effective flow network.

In conclusion, outside influences did not materially change the optimal flows for Carlstar as much as influences under Carlstar's control. The largest levers, handling costs and demand, are functions that Carlstar has the most control over. Thus, Carlstar is in a great position to weather swings in both transportation and tariff rates.