Planning for Peak Demand in Reverse Logistics

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Summary: The project sponsor is a reverse logistics company that provides Returnable Transport Items (RTIs) to large manufacturing companies, distributors and retailers. The seasonal peak demand for RTIs from June to September negatively impacts service levels and costs. The sponsor company seeks an opportunity to level load production and build inventory position, while optimizing the service levels and annual supply chain costs. This capstone project proposes an optimal supply chain plan by analyzing historical data, identifying key cost-service drivers and creating a Scenario Planning Tool (SPT) that demonstrates tangible benefits in terms of cost and service level improvements.

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KEY INSIGHTS

1. Correlation between inventory policies and supply chain costs have been identified in this project. Understanding the quantifiable impact of changing the days of coverage gives an opportunity to optimally plan inventory coverage to minimize supply chain costs while meeting service level targets.
2. Increasing inventory days of coverage beyond a specific point would not create incremental value. Hence, building up inventory to increase days of coverage after the threshold is reached would only add to costs without improving service levels.
3. Transportation and logistics form the largest cost component in a typical closed-loop supply chain. This is mainly explained by the fact that every product circulates in the closed-loop network a few times before being discarded. Hence, it would be critical to compare the transportation and relocation cost savings against the cost of adding new products into the closed-loop supply chain network when determining the optimal inventory policy.

Introduction

Returnable Transport Items (RTIs) are defined as objects used for the purpose of “transportation, storage, handling, and product protection in the supply chain, which are returned for further usage”. Examples of RTIs include bins, kegs, pallets, and racks. They are used across various industries for internal and external movement of raw materials, semi-finished products and finished goods. Current estimates place the number of active RTIs in the United States at more than 2 billion units, utilized to transport 80% of the country’s trade.

The project sponsor is a reverse logistics company that provides RTIs to large manufacturing companies, distributors and retailers. Its business model is characterized by a unique closed-loop supply chain.

They issue ready-to-use empty RTIs to its customers. As seen in the flow of Figure 1, the customers load their products onto these RTIs and ship them through their supply chain. The RTIs are then emptied and offloaded, and returned to the sponsor company, typically to the nearest service center. At the service center, the sponsor company inspects all returned RTIs and separates RTIs which need repair. Damaged RTIs are cleaned, repaired and certified for use before being shipped out again.

Figure 1: Illustration of the sponsor company's closed-loop supply chain

The demand and supply of RTIs follows a seasonal pattern. The demand peaks before the holiday season, when manufacturers and retailers stock up products to sell during the holiday season. This causes a spike in demand for RTIs during June to September, leading to depleting inventory levels and lower service levels. In order to meet this demand, new RTIs are injected into the system. Production of new RTIs needs to be ramped up, thus straining capacity and increasing cost. Post-holiday season, the retailers and distributors are left with empty RTIs, which they transport to the sponsor company. Returning the used RTIs is largely the responsibility of customers and the sponsor company cannot dictate the timing of these returns. This lack of visibility makes planning during the peaks and troughs even more complex. Post peak demand season tends to experience an enormous supply of returning RTIs to the service centers of the sponsor company, putting a strain on repair and storage capabilities and increasing repair costs.

Given the significant challenges in optimizing service levels, cost and inventory, due to the huge variation in demand and supply coupled with the lack of product visibility in the closed-loop supply chain, the sponsor company seeks to level load production and build inventory, while holistically considering annual supply chain costs. A series of factors (timing of demand, supply, production, storage, inventory position and other relevant parameters) need to be considered and decisions need to be made in the prior eight months to manage the critical four months. To address the projected growing demand, it is also imperative to facilitate long-term planning across fiscal years to prepare the supply chain to manage peak demand during critical months.

Methodology

The scope of this project includes leveraging the sponsor company’s historical data to develop a scenario-planning tool which will forecast the correlation between supply chain costs and service levels based on various inventory policies. The methodology is as follows:

- Analyze historical key performance indicators and identify statistically significant key drivers that impact service and cost
- Recommend an optimal supply chain plan - in terms of adjusting inventory days of coverage to optimize supply chain costs and service levels
- Quantify impact on cost and service levels by changes in inventory policy

Both linear and non-linear regression models were used to explore correlational effect between days of coverage and the various supply chain costs. From the models developed, we would then be able to (a) check the validity of our hypothesis and assumptions, (b) test the correlation parameter coefficient and validity and (c) estimate the optimal inventory plan and use the model for prediction purposes.

The sponsor company's S&OP (Sales and Operations Planning) data were concurred with the cost components to evaluate the correlation between cost and serviceability metrics. Key observations were flagged and the correlation framework was developed. One key observation is illustrated below:

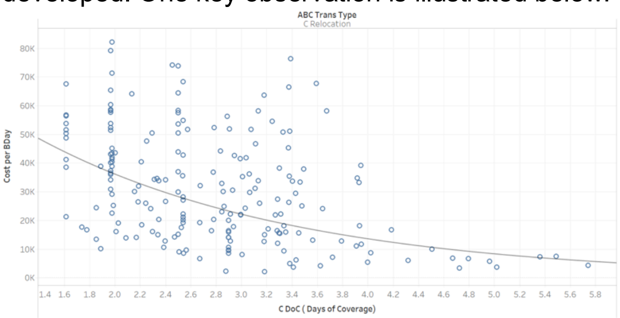

Figure 2: Illustration of regression correlations between the ready-to-use RTI inventory and the costs associated with moving ready-to-use RTIs between distribution centers

It is observed that there is a statistically acceptable correlation and inverse relation between the ready-to-use RTI inventory and the costs associated with moving ready-to-use RTIs between distribution centers. This implies that as the ready-to-use RTI inventory across distribution centers increases, the relocation of RTIs between distribution centers reduces, and vice versa. This is because more distribution centers have enough ready-to-use RTIs to satisfy demand from the nearest location. As a result, there is a lower need to "borrow" inventory from other distribution centers, reducing the amount of relocations needed. Hence, by maintaining a healthy level of ready-to-use RTI inventory at each distribution center, the internal relocation and transportation can be minimized, thus reducing the associated relocation costs.

Similar correlations were explored for other relocation costs and service metrics, and plotted in the Scenario Planning Tool (SPT). The SPT is an interactive tool that models the monthly inventory position across entire calendar year, based on the monthly cost and service metrics. It creates a user-friendly interface which accepts monthly data on cost and service parameters, calculates the inventory position, and presents the supply chain plan, based on key assumptions and regression coefficients. It can be used in different ways to monitor, predict, optimize and improvise the supply chain metrics, based on the functional and organizational requirements. It can be used to develop an optimal supply chain plan that maximizes service levels, while minimizing the total annual supply chain costs. As the tool also compares the baseline versus optimal inventory position and corresponding costs, it can be used to benchmark the existing data to the optimal position, and well as perform a sensitivity analysis to analyze the impact of any change in inputs on supply chain cost and service levels. Based on the regressive correlations, predictive power and optimization using the SPT, the optimal inventory plan was created for the years 2010 to 2017. The results showed that the optimal supply chain plan can lead to an improvement of 5%-24% cost and up to 6% service level.

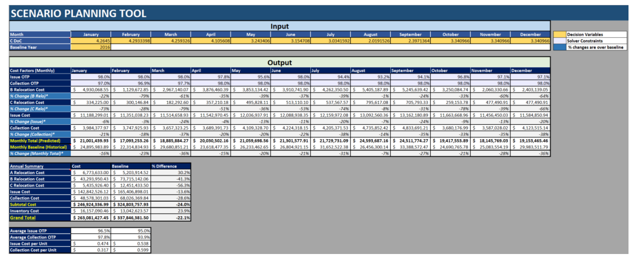

Figure 3: Illustration of Scenario Planning Tool (SPT)

The SPT was tested for multiple scenarios to create a robust model, which would optimize the combined cost and propose scenarios to maximize serviceability while adhering to relevant system constraints and variability.
Historical S&OP data was also loaded into the SPT to allow for users to compare future scenarios to a baseline scenario. The functionality of comparing future scenarios to the baseline also acts as a way to quickly check for feasibility of the future scenario itself.

Conclusion

Correlation between inventory policies and supply chain costs are identified in this project. Understanding the quantifiable impact of changing the days of coverage gives an opportunity to optimally plan inventory coverage to minimize supply chain costs while meeting service level targets. In addition, the exponential trends found in historical data contribute to the phenomenon where 100% service levels are achieved before minimal supply chain costs are attained. This would mean that there is a threshold after which increasing days of coverage more would not create incremental value. Hence, further investing in inventory policies to increase days of coverage after service levels are met is not necessary. Another critical finding is that transportation and logistics cost is the largest cost component in a closed-loop supply chain for returnable transport items (RTIs). This is mainly explained by the need to replace only a small amount of RTIs every product cycle. Hence, it would be interesting to compare new product costs will be with transport and logistics costs as a next step, to determine the optimal closed-loop supply chain flow.

The concepts explored in this study build on the understanding of how different supply chain costs and parameters interact with one another. The study is aimed to aid better decision making for functional and organizational teams, while planning their supply chain. It is hoped that this study shall not only guide the company itself, but also the broader ecosystem, in order to design and implement holistic supply chain policies.