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Enhancing Performance in a Hub Distribution System
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Enhancing Performance in a Hub Distribution System

By Agnes Wambui Maina and Sneha Susan Jacob
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This thesis investigates the best possible solution to enhance performance in a Hub Distribution System throughout the supply chain by increasing the service level to the affiliates (also known as Demand Areas). This will enable the company to identify the impact of operating policies based on a set of planning parameters (Lead-Time – from the hub to the manufacturing facility and the hub to affiliate and Ordering Frequency) and inventory policies. A five-step methodology is employed to analyze the problem at hand and develop a solution for the same.

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KEY INSIGHTS

1. Risk Pooling results in savings in the total inventory held in the system. Although, at shorter lead-times, the savings are much greater.

2. By reducing Lead-time and/ or Ordering frequency, higher Service Levels could be offered for the same Safety Stock investments.

3. To mitigate the risk of obsolescence and quality rejection at the affiliates, the RSL must be atleast 10% above the acceptable RSL at the point of entry to the hub.

Introduction

In the past, the transportation and distribution industry was guided by the principles of point-to-point or direct-route operations. As technology developed, the logistics sector found faster and more cost-effective ways of shipping freight. The hub-and-spoke model where all flows are routed through a hub was born from the industry's efforts to develop more efficient networks. This in turn was shown to increase customer satisfaction and organization competitiveness which are contingent upon improving performance including streamlining material movement and minimizing inventory.

For pharmaceutical products, the shelf life is a key value to end consumers. Service-oriented supply chain contracts with penalties of shortage require companies to meet an agreed service level and keep safety stock to mitigate uncertainty. On the other hand, having excess inventory will incur high inventory cost and, in the case of perishable products, obsolescence cost.

Benchmarking by Firm Ticatoe has shown that leading competitors have started developing Intermediate Inventory Storage Points (IISP) with Secondary Packaging nearer to the markets to speed up deliveries and reduce costs. Firm Ticatoe currently has a Direct Shipment strategy and intends to move to an Intermediate Inventory Storage Point strategy.

Company Ticatoe manufactures medicines in the clinically differentiated medicines segment which are packed and shipped to distribution centers in a number of regions with differing cultures and languages. Such diversity raises the need for redressing (Different labelling and Art work unique to each language region) which in turn multiplies the number of SKUs the company produces. The market regions that the new Intermediate Inventory Storage Point with a Secondary Packaging Hub will serve have highly stochastic demand during certain points of the year and forecast errors for these demands have been high. Distance from the Manufacturing Plant to the Affiliates (Areas of Demand) require lengthy lead time, while at the same time, the company's products are perishable goods subject to limited shelf life and regulatory policies surrounding them. Those constraints prompted the company to postpone product differentiation of all the products in the Asia Pacific region. An optimal safety stock level will minimize wastage while meeting service level, which will eventually minimize costs related to keeping perishable safety stock.

Due to a change in the Supply Chain Strategy, Firm Ticatoe would like to know whether a change from its current strategy could improve its supply chain performance by increasing service levels to the affiliates. This project is motivated by a need to determine the impact of alternative operating policies and supply chain parameters on the IISP's supply chain performance, i.e. service level, stock-keeping costs, write-off costs, comparing base case (no hub) with alternative options and scenarios.

Literature Review

The trade-off between service level and safety stock can be depicted by an "exchange curve" between service and inventory turns. With the same customer service level, increasing postponement is expected to reduce inventory and increase inventory turns. The two most common approaches to determining a safety stock level are through a basis of minimizing cost as well as a basis of meeting a predetermined customer service level (Silver, Pyke, & Peterson, 1998).

The approach based on minimizing cost explicitly or implicitly assigns a cost to a stock-out occurrence and then attempts to minimize the total cost by assessing the trade-off between the stock-out cost and the holding cost of excess inventory. The approach based on meeting a predetermined customer service level however, uses a statistical analysis of the product demand lead time to determine the appropriate safety stock level necessary to attain or exceed the service level constraint. Facing the reality of a stochastic product demand rate, the majority of non-perishable Inventory Management literature focuses on the derivation of optimal or near optimal stock levels with regards to three common inventory control policies (Silver, Pyke, & Peterson, 1998).

Methodology

A five-step methodology is employed to analyse the problem at hand and develop a solution for the same. Extensive search of published materials, Validation of knowledge from industry experts, Conducting a statistical goodness-of-fit analysis using a commercial Excel add-in package to fit the distributions across the affiliates, Development of a deterministic model which aided to determine the optimal quantity to order, safety stock and re-order point for this study. This model also helps in determining what the holding costs would be for cycle stock, safety stock and pipeline inventory as well as the associated transportation costs. This was determined by having a set of variable input parameters such as lead-time (from the hub to the affiliates and from the Manufacturing facility to the hub), order frequency, product review period and Cycle Service Level (CSL). After analyzing the deterministic process, we further expanded the deterministic model to a stochastic one with the main aim of giving us a brief overview into how the effect of the change would vary by putting a range to certain input variables that gave it a more real life outlook to the situation at hand.

Results

1. Risk Pooling Analysis, using the hub for secondary packaging would result in tremendous savings with regard to the expected inventory held at the end of the lead-time period and substantial savings in the total inventory held in the system. In order for Ticatoe to increase the savings resulting from using the hub for secondary packaging, we propose a reduction in the lead-time from the manufacturing plant to the hub. By reducing the lead-time from the current 90 days, Ticatoe would consequently reduce its investment in pipeline inventory thus increasing the savings in the total inventory in the system. The impact of lead-time reduction on the savings is depicted in Figure 1 below.

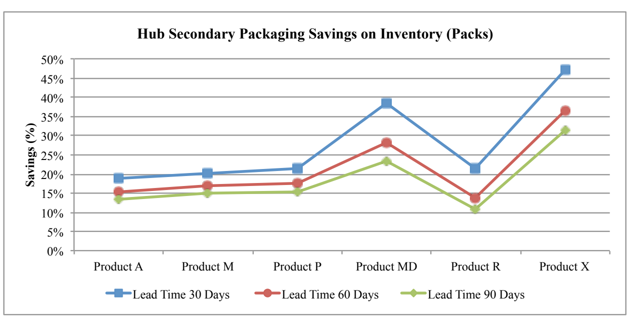

Figure 1

2. Using the hub for secondary packaging would result in huge savings for products which exhibited high variability. Reference to Table 1, Statistical Analysis, Product X and Product MD, are high volume products and they had relatively high coefficient of variation compared to the other products. Therefore, by holding un-differentiated products at the hub, Ticatoe would pool the demand variability thus resulting in greater savings. This applies for any lead-time period as depicted in Figure 1 above although at lower lead-time the savings are greater.

Table 1 -

			Monthly Order Data: 2012 - 2014				
Product	**Affiliate**	**Months Without Orders**	**Highest Monthly Order**	**Lowest Monthly Order**	**Average Monthly Order**	**Monthly Standard Deviation**	**Coefficient of Variation (COV)**
A	Hong Kong	1	3,614	1,877	2,599	654	0.25
	Malaysia	0	2,850	268	445	408	0.92
	Thailand	0	2,366	1,337	1,732	300	0.17
	Taiwan	0	12,483	6,828	9,116	1,452	0.16
	Vietnam	18	3,750	500	903	339	0.38
	Total	0	10391	22108	14,795	1,705	0.12
M	Hong Kong	0	670	175	264	112	0.42
	Malaysia	0	112	20	57	30	0.53
	Thailand	0	278	185	231	28	0.12
	Taiwan	0	803	326	593	167	0.28
	Vietnam	31	168	50	20	7	0.34
	Total	0	761	1,589	1,165	205	0.18
P	Hong Kong	-	-	-	-	-	-
	Malaysia	0	6,950	620	3,291	1,546	0.47
	Thailand	0	9,048	1,597	3,950	1,728	0.44
	Taiwan	0	14,616	11,094	12,736	925	0.07
	Vietnam	4	10,105	1,964	4,099	1,339	0.33
	Total	0	17,293	28,786	24,076	2,833	0.12
MD	Hong Kong	0	3,389	1,345	2,032	534	0.26
	Malaysia	0	10,462	839	3,263	3,274	1.00
	Thailand	0	10,884	7,185	8,492	1,356	0.16
	Taiwan	2	21,460	12,526	15,961	4,502	0.28
	Vietnam	33	297,045	227,045	22,809	9,739	0.43
	Total	0	12,204	327,114	52,557	11,312	0.22
R	Hong Kong	0	20,509	5,367	12,995	4,711	0.36
	Malaysia	0	1,213	23	494	320	0.65
	Thailand	0	6,167	2,315	4,634	1,294	0.28
	Taiwan	0	67,762	51,000	62,355	4,422	0.07
	Vietnam	-	-	-	-	-	-
	Total	0.0	62,046	92,470	80,478	6,597	0.08
X	Hong Kong	0	7,446	1,913	4,897	1,324	0.27
	Malaysia	6	27,029	120	6,718	5,769	0.86
	Thailand	0	7,957	3,132	5,145	1,483	0.29
	Taiwan	0	9,375	411	1,599	1,843	1.15
	Vietnam	33	32,160	22,160	2,402	1,543	0.64
	Total	0	8,916	42,105	20,761	6,558	0.32

3. Another key benefit of using the hub for secondary packaging, Risk Pooling Analysis, is that Ticatoe could achieve the same fill rate with lower investment in inventory. Conversely, Ticatoe could offer higher fill rate at the same level of investment in inventory as depicted in Figure 2 below.

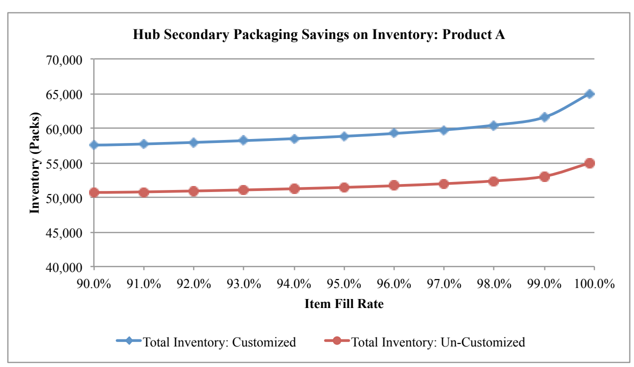

Figure 2

4. Safety Stock Analysis, we realized that some affiliates exhibited great variability in their

product demands and thus, in order to maintain high service levels, the affiliates would have to invest heavily in safety stock as depicted in Figure 3.

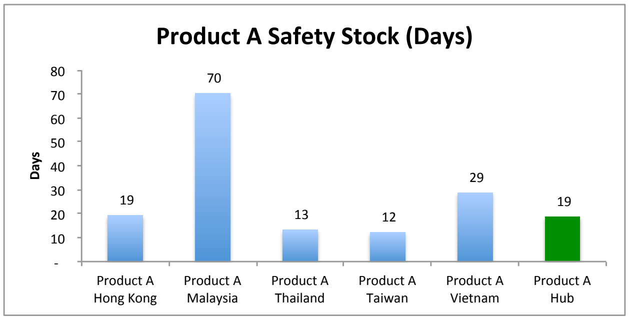

Figure 3

We propose, "restricting" the demand that can be serviced from the affiliates and the hub for the low volume products. Restricting the demand results in lower safety stock levels. With demand restricted to one-sigma, safety stock levels were reduced by about 20% at cycle service levels higher than 98%. Figure 4 indicates that the hub would have to trade off between low safety stock levels and high service levels as well as whether to limit the demand that could possibly be serviced from the hub.

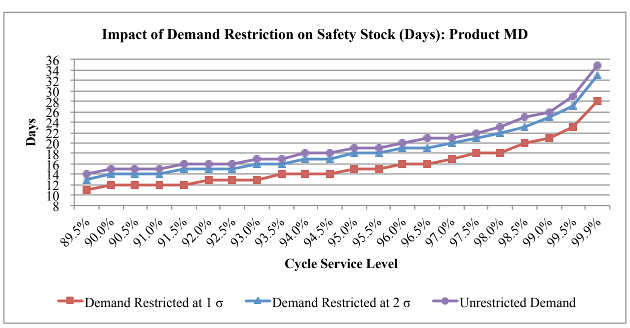

Figure 4

5. Sensitivity Analysis, increasing the lead-time increases the safety stock across all cycle service levels. Second, increasing the CSL also increases the safety stock non-linearly with an "exponential" increase from about 97% towards 99.99% for each lead-time period considered. For each lead-time period, improving the CSL from 89.5% to 99.99% necessitates investment in safety stock as depicted in Figure 5 below. However, Ticatoe would have to invest about an additional 64% in safety stock to improve the CSL from 97% to 99.99% as compared to about 30% investment in safety to improve CSL from 89.5% to 95%. As stated with reference to CSL and with reference to the safety stock formula, as k increases, it gets more difficult to improve the CSL and it will require enormous amount of inventory to cover the extreme limits. Therefore, we recommend Ticatoe to reduce the lead-time from the manufacturing plant to the hub so as to reduce safety stock investment at the hub.

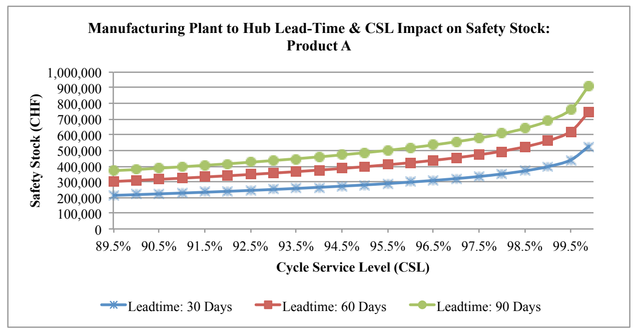

Figure 5

6. Figure 5 above indicates that by reducing the lead-time and/or ordering frequency, Ticatoe could possibly offer higher cycle service levels for the same safety stock investment. For instance, at CHF 500,000 investment in safety stock, the corresponding service levels are 95.5% when the lead-time is 90 days, about 98% when the lead-time is 60 days and almost 99.7% when the lead-time is 30 days. Second, with a target CSL and target lead-time and review period, Ticatoe could determine the expected investment in safety stock. Third, Ticatoe could free up some working capital by shortening the lead-time from the manufacturing plant to the hub.

7. Residual Shelf Life (RSL), different products have different minimum acceptable RSL across the affiliates. However, for the products under consideration, the RSL requirement is similar across the affiliates to which they are imported as indicated in Table 5. For a product to be imported to the affiliate, the product ought to have the prevailing RSL greater than the minimum acceptable RSL at the affiliate. Figure 6 indicate the RSL usage and acceptable RSL at the affiliate for Product A.

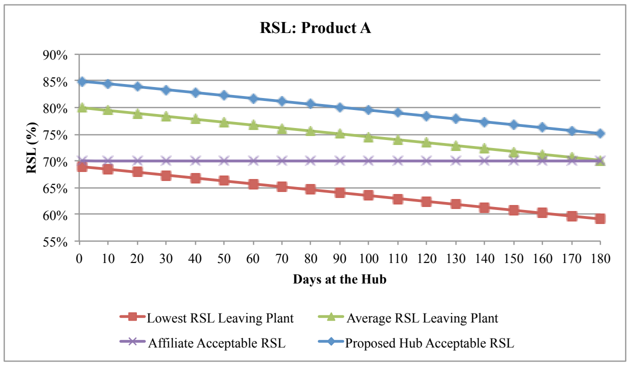

Figure 6 Implication of the regulatory policies associated with RSL

Our analysis revealed that it would be prudent to have a buffer against the products becoming illegal for importation to the affiliates. Therefore, for all the products, we propose for the RSL to be at least 10% above the respective affiliate acceptable RSL at the point of entry to the hub. Such a practice would mitigate the obsolescence risk at the hub and quality rejection at the affiliates' centers.

8. From section 4.5, Scenario Analysis, the total costs also increase with increase in order frequency and lead-time although lengthening the lead-time results in greater surges in total costs compared to increasing the order frequency. From a cost perspective, we propose reducing the lead-time from 90 days and placing orders fortnightly or monthly would be more cost effective as compared to the present situation as depicted in Figure 12. Currently, the lead-time from the manufacturing plant to the affiliates is 90 days, the affiliates order product A, M and P monthly, they order product MD and X quarterly and product R half yearly.

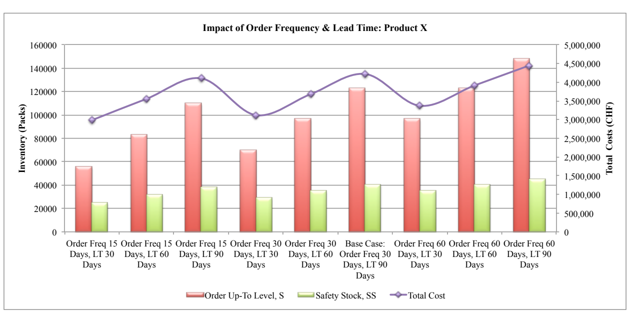

Figure 12: Impact of ordering frequency and lead-time on inventory and total costs

9. The introduction of the Intermediate Inventory Storage Point also has the capability to reduced the end to end stock keeping into account that the lead-time to and fro is reduced and the affiliates do not store much safety stock since the renewal time for the same is now much lesser. This can also be brought about by the outlook on the demand restriction for safety stocks.

Conclusions

In conclusion, by using the hub for secondary packaging thus holding un-differentiated products, Ticatoe will greatly benefit from the demand pooling of products which exhibit high variability in demand: Product X and Product MD. However, we are of the opinion that Ticatoe should aim to reduce the manufacturing plant to hub lead-time from the current 90 days for all products and also reduce the ordering frequency for the temperature controlled products; product MD, R and X so as to benefit from lower costs at any given CSL. Second, by reducing the lead-time from the manufacturing plant to the hub, the resulting inventory savings from using the hub for secondary packaging will be greater due to lower investment in pipeline inventory.

Although the main focus in thesis has been on the impact of two supply chain parameters, lead-time and ordering frequency, on the performance of the hub, further analysis could be done to future on the impact of other supply chain parameters on the hub performance.

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