Supply Chain Network Optimization: Low Volume Industrial Chemical Product

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Summary:
This research project studies the global supply chain network flow of a low volume low margin industrial chemical product. It presents a network optimization model to minimize the total cost-to-serve (C2S). It also includes three scenarios to compare C2S when supply capacity shifts.

Introduction
The chemical industry is a highly competitive and low margin industry. Chemical transportation faces stringent safety regulations meaning that Cost-To-Serve (C2S), costs associated with products net flow from manufacturers to customers, consists of a big percentage of the delivered product cost. TopChem Inc. is a large manufacturer and distributor of a wide range of chemical products. SKU-1 is a solvent with multiple applications for industrial and household products. Its global supply chain is dispersed and complex. To maintain low C2S, the company is interested in evaluating its C2S structure and impact by potential supply and demand shifts. This research project develops a network optimization model to answer these questions.

Methodology
Our network optimization model consists of defining model parameters, setting objective function, and incorporating business constraints. In model parameters, we define cost components of C2S, supply capacities, demand requirements, and shipped quantity among nodes. The objective function is to minimize the total supply chain costs of SKU-1 from manufacturers to customers with constraints of supply capacity and customer demand being met.

TopChem Inc. provides us with a set of data to facilitate our modeling process. The data include cost components of C2S from node to node, such as costs of manufacturing, transportation, railcar,
terminal and inventory holding. The company also provides us with information of its supply capacities and customer demands. In addition, we use linear regression to calculate some of the truck and rail rates that are not available.

We set up three scenarios to study C2S impact by supply shifts. The Baseline scenario is the supply network with manufacturing capacities at Southeast, Midwest and Europe. Scenario 1 evaluates the cost with Midwest facility taken out of the network, while Scenario 2 with Europe as the sole manufacturing source. Scenario analysis complements the optimization solution by presenting a scope of future developments.

**Findings**

Our model reveals that, as the supply is constrained, the company is forced to supply its Midwest customers from manufacturing or terminal facilities that are further away, resulting in higher total C2S—a 3% increase in Scenario 1 and 13% in Scenario 2. Accordingly, total C2S increases from $12.2 MM in baseline scenario to $12.5 MM in scenario 1 and $13.9 MM in scenario 2.

Our cost driver analysis shows that cost components of C2S change as supply shifts. In Scenario 1, as the company jointly utilizes its Southwest manufacturing facility and Northeast and Eastern Canada terminals to meet its Midwest customer demands, we see a meaningful cost increase in stock movement to terminals (6.6% vs. 5.4% of C2S in scenario 1) and Freight to Customer (3.7% vs. 3.2% in scenario 1). In scenario 2 where the company needs to bring all products from Europe through golf coast terminal, we witness a big cost increase in terminal handling (6.2% vs. 3.7% of C2S in Scenario 1) and stock movement to terminals (9% vs. 5.4% in scenario 1). Figures 1 and 2 show these results.

Our product flow analysis reveals that the supply shift changes the way products flow in the network. In scenario 1, we see a big increase in quantity handled by its Southeast, Eastern Canada and Northwest facilities. (131%, 39% and 56% increase compared to in baseline scenario 1) In scenario 2, since all products come from Europe, we see a huge increase in quantity handled by the golf coast terminal, while the usage of its Eastern Canada and Northeast terminals stays high. (58% and 56% increase compared to in baseline scenario)

Our analysis of C2S by customer shows that C2S impact on customers varies in different scenarios. In Scenario 1, the C2S to some customers can be increased by 20% from that in baseline scenario, while it remains unchanged to others. In Scenario 2, it can be increased by 37%, while by only 4% to others. The highest cost increase generally happens to those customers that are close to its Midwest manufacturing facility. Yet because of supply shift, they will have to be served from facilities further

![Figure 1: Manufacturing as % of total C2S](image)

![Figure 2: Other Costs as % of total C2S](image)
away, incurring more transportation and/or terminal costs.

Our analysis of South America C2S with increased demand reveals that, as its demand fast growing, more products need to be brought in. Since C2S to South America is high, its growth of C2S as a percentage of total C2S is much faster than that of its demand growth as percentage of total demand.

Figure 3 shows the projected demand growth of 20% per annum. The C2S in South America as a share of the total increases from 29.3% in year 0 to 46.7% in year 4. Yet, its demand of the total only increases from 27% to 36%.

![Total and South America C2S](image)

Figure 3: South America C2S with increase in demand

**Conclusions**

TopChem Inc. is in the commodity-type competitive chemical industry. It needs to keep its C2S low while serving customers’ demands to be profitable. Given its global supply chain span, a potential supply shift will pose huge impact on its product flow, resulting in C2S changes accordingly. In this project, we build a network optimization model to find the solution of its C2S in baseline Scenario. Our analysis expands to two other scenarios. In Scenario 1, we take Midwest facility out. In Scenario 2, both Midwest and Southeast facilities are taken out. We see total C2S increases by 3% in Scenario 1 and 13% in Scenario 2. Our analysis also reveals that C2S impact on individual customers vary greatly as customer location, transport mode, and service options all play important roles in deciding C2S.