Supply Chain Management in Oil Downstream Distribution Business: A perspective on IT Alternatives and Issues

Abstract

The oil downstream distribution segment is increasingly adopting a variety of supply chain solutions. From crude selection to product distribution at the retail outlet, it is a chain with many links. The unpredictability in oil prices, refining margins and the long lead times associated with vital functions like crude buying and product trading make the entire process challenging. The product development companies have introduced some good products in the SCM space. Implementation of these solutions on large installations, however, is what the world is watching, as huge oil companies struggle to "chain" the business. Integration with existing IT solutions used in the industry is also a major challenge in the sector. The industry has a pressing need for both implementation and integration skills for taking the best value out of the different supply chain solutions available. The question is, will the elephant dance?

Introduction

When Peter Florack swerves in his Toyota Camry into his neighborhood gas station in California, he has a choice of different grades of gasoline, which he can load into his beauty. The gas station is a model, modern filling station with all the amenities the residents of this suburb would expect: pay-at-the-pump lanes, a 24-hour convenience store, and a car wash. Florack goes for the 95 RON grade, which he feels makes his car zip out that much faster, and of course, he is okay with the small premium he has to pay for that.

Underground, the gas station is as modern. The tanks for super unleaded and for regular (the midgrade fuel) are larger than the normal tanks. Each tank is equipped with an electronic level monitor that conveys real-time information about its status through a cable to the station's management system, and then via satellite to the main inventory management system for the oil company whose products the gas station markets. When Florack fills up his Toyota, the gas station will have only 2,678 gallons of the super unleaded and unless the tanks are filled out in 6 hours, the station will run out of gas. However, the station has never had a run out since it opened a year ago.

The gas station above is among the many dotting the landscape in Central and West America that are getting connected to the supply stations on real-time basis. The data, which is available across the gas stations, and the integration work that allows it to be shared across the company can improve decision making at every point in what the industry calls the downstream, or customer-facing supply chain that begins once the oil is earmarked for the refinery. (The upstream chain includes exploration, production, and pumping of crude oil).

The movement from the supply-driven push to a demand-driven pull is slowly taking place in the segment. Where once the challenge was in getting the best deals on buying crude, the focus is shifting to give customer what he wants. Couple this requirement with the fact that the crude buying window closes a month in advance and we need a supply chain, which should have no weak link.

Components of the Downstream Supply Chain

The downstream business is divided into Refining and Distribution segments. This paper focuses more on the Distribution segment. Since there is a lot of interplay between the two segments, a brief description of the Refining business is also included.

The important components of the Refining business supply chain and the interplay between them is shown below. All the important functions in this business are enabled by IT applications, which optimize the different portions of the value chain.

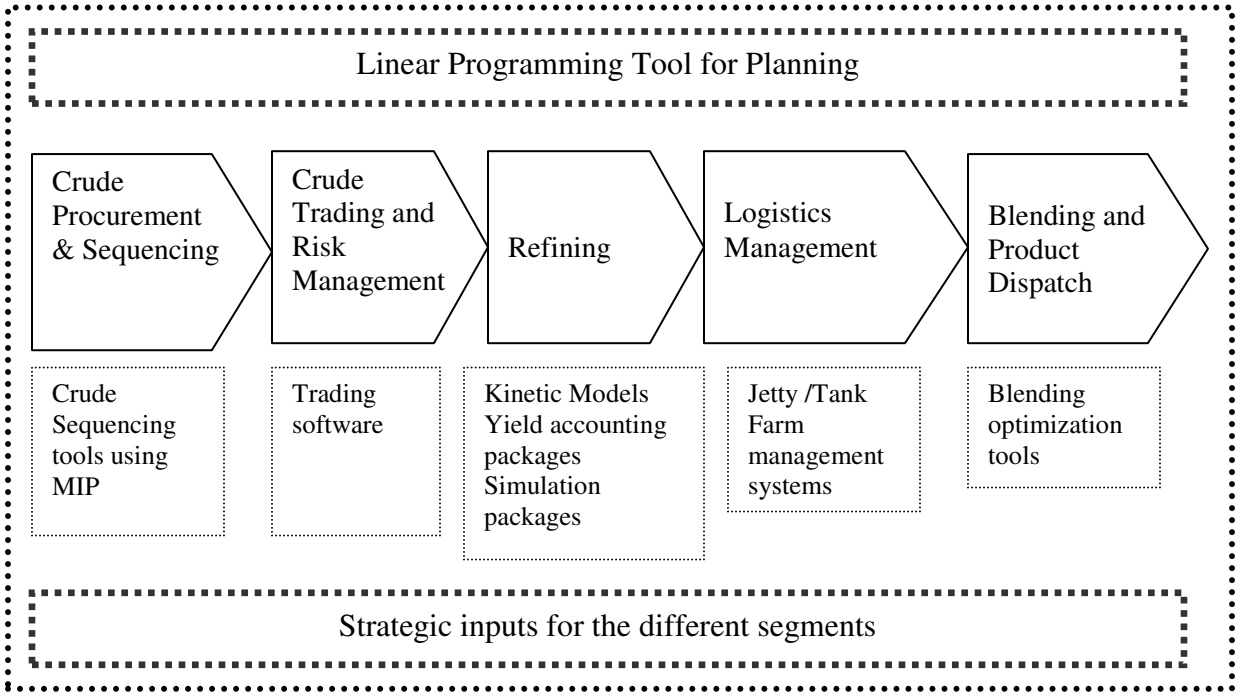

Exhibit A: Value chain for refining business segment with applications

The Refining business segment supply chain is managed by using linear programming packages, which can evaluate crudes, schedule cargoes, and blend streams to give products. In addition, in manufacturing, kinetic models and yield accounting packages optimize the performance of different conversion units. The major challenges in the supply chain in this sector are the integration of all these packages with the trading software and with transaction tracking packages like SAP. Hence, even considering the benefits of LP (Linear Programming?) and scheduling tools, the disconnect between the kinetic models, yield accounting packages, trading software and the LP does leave some room for making the supply chain more responsive and headed in a single focused direction.

Now, let us move to the distribution segment whose vital links are as shown below.

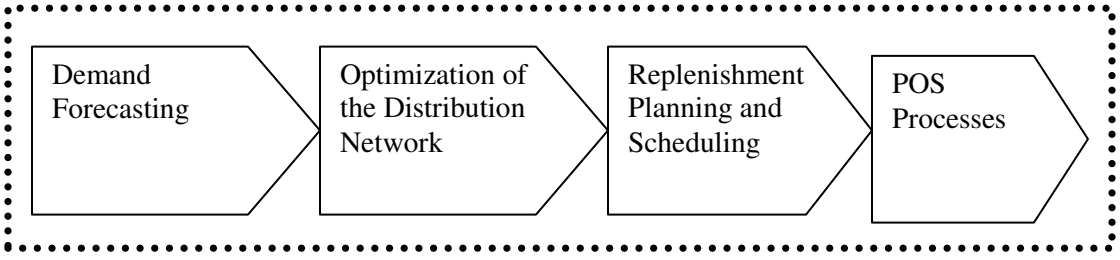

Exhibit B: Vital links of Distribution segment

The above functions are also enabled by different IT applications. Seamless flow of information across these functions is vital for streamlined performance of the value chain. The distribution segment is discussed in more detail below.

Distribution Segment

There is a definite shift in focus in the industry toward the distribution segment. The big oil companies have started monitoring the inventories of gas stations and are using the demand data from such outlets to plan for the refinery throughputs. The issues at the refinery level are: Which crude to use? Which units to run? Which products to make and in what quantities? While the issues at the customer facing end or at the gas stations are basic, namely, run outs and retains. Run outs is loss of customer as the station has no gas and can potentially turn away the customer forever also. Retains are slightly manageable as they involve just the demurrage which has to be paid for holding a loaded truck till there is ullage in the station's huge tanks. But these issues are now beginning to impact at how the big brother is operating. How the entire supply chain is gearing up to address these issues is the challenge in front of the oil companies.

There are two objectives from the point of view of supply chain integration in the downstream distribution segment, viz.:

1. To get data from the POS and other sources so that the demand forecasting numbers are accurate, and integrate this data so that the refining business has a good idea about the different demand numbers of different products.
2. To optimize further within the distribution sector itself so that the costs are minimized.

The important functions within the distribution segment are demand forecasting, optimization across alternative means of transportation, replenishment methods to avoid retains/run outs and finally scheduling, which sequences the dispatch. Let us look at these functions in a little more detail.

1. **Demand forecasting**: The demand number for each product for the forward month is one of the key inputs, which is essential for the refinery LP to perform the optimization studies. This input actually determines the rate at which the refinery operates for the next month. This decision helps in buying crude so that there is no "dry-out" or lack of crude for running the units, or demurrage due to a high inventory build-up. The demand numbers are generally taken based on following inputs.
    - Historical data for the similar period
    - Forward trades data, based on deals done or committed in the forward months
    - POS systems which give the latest updates
    - Macroeconomic indicators reflecting the economy
    - Marketing inputs based on marketing plans to introduce new schemes, etc., in a month for attracting customers
    - Meteorological department's inputs, as the gasoline and heating oil requirements are very weather sensitive

    Even though all these inputs are considered, an element of subjectivity comes in while giving weightages for each of these factors. The weights can vary with time or with individuals, leading to different predicted numbers.

2. **Supply and distribution plans**: The logistics management group coordinates the movement of products from the refinery gate to different customers and retail outlets. Movement of

products by ships needs proper jetty management and scheduling. A ship waiting to be loaded/unloaded costs demurrage (a crude VLCC alone incurs around $30,000 /day of waiting) and the customer waiting to get the cargo may also levy penalty clauses for the delays. If there is a delay in product evacuation due to improper scheduling, the product tanks get filled up and leading to a chance of throughput reduction of the refinery itself. In worst cases, there is a chance of crude vessels incurring huge demurrage. On the other hand, the early arrival of product vessels may lead to insufficient stock in the tanks and there would be dead freighting which is uneconomical.

For products moving through pipelines, pipeline scheduling is important. Pipelines would typically pump batches of around 1,000 kt. These batches cannot be normally interrupted. Also, the material, which was pumped before and after the product, has an impact on the quality of the interface and needs to be considered during pipeline scheduling. In most of the refineries, the objective is just to move the right material from one place to the other at the right time, which in itself is considered a challenge. Such methods are not necessarily the best or optimum methods. But in these times of severe competition, margin is in the range of 8-10 cents/barrel on distribution methods are considered really attractive. The focus has moved from just delivering the right amount of the material at the right time in right quantities to delivering all that at the least cost.

3. **Replenishing the retail outlets**: The fundamental issues for a gas filling station are run outs and retains. Both run outs and reruns are discussed earlier. Even though there is a weekly and monthly plan for distribution for all the gas stations, the scheduling for refilling of these stations needs to be done properly. If there were unlimited tankers topping up these gas stations, there would be no issue. But typically there would be a single tanker, which would cater to a neighborhood having many filling stations, and its optimum utilization means better utilization of the tanker itself as well as prevention of run outs and reruns. It makes economic sense too as each fruitless visit of a tanker costs around $150 and with a midsize company having around 4,000 outlets, these costs add up fast.

Common Issues

1. Most oil companies use some sort of software application developed by their own teams to address the areas of demand forecasting, supply and distribution planning, replenishing planning and scheduling. What is lacking is the benefit of an integrated system that can look across the value chain. The proprietary software can deliver in 90% of the cases but is not good enough in this fiercely competitive segment.

2. Many oil companies, particularly the big ones, are actually going for integrated applications in this sector. But for them, the main issue is integrating these applications with other applications like SAP, kinetic models, yield accounting models, trading software or even the LP, for the refining business. Hence, there is always a disconnect in the tools being used.

3. One of the big issues is the difficulty in predicting the forward price, which will prevail in the market in the future months. Some indications are of course available with the futures prices prevailing in the exchanges. Some companies hedge their margins or crude prices by doing paper trading. The forward price is a vital input in the optimization process and can actually drive the model for a particular product maximization based on its price.

There are new tools and products available in the market that claim to address all the issues in the distribution segment. Let us take a look at some of the tools available in the market for the different segments of the downstream distribution business.

Software Tools Available

1. **Demand Forecasting**: A variety of models are used for answering the basic question of how much product will be needed at each of the terminals for a particular time period. Intelligent neural network algorithms are being used for making such models. The Neural Network simultaneously evaluates various statistical forecasting methods and weighs them according to their accuracy as compared to historical data to create a composite algorithm. Some of the attributes of this function, specifically desired for bulk refined product demand planning are:
    - Demand planning by individual product and customer/channel of trade
    - The demand plan to be done over different time periods (short, medium, long-term)
    - The economic impact and the effect of price and availability of a substitute for products on demand to be considered

    The demand forecasting tool using Neural Network apply the forecasting methods like daily average, day of week average, seasonal, etc., which learns from past experience and projects for the future. These models use other functionalities like Linear Regression, which find the best straight line through the last two years of data and extrapolate this line into the future to predict future sales. Sometimes, exponential regression, which attempts to best fit an appropriate exponential function using power regression where the data is best fit according to a power function, is used.

    The forecasting tools have evolved to such an extent that they allow users to modify or enhance the forecast using other tools for sales anomalies that the system would have no way of predicting. Sometimes, the users need to retrieve from the historical database an "event" that caused a fluctuation in demand. They can then map the historic sales patterns of those days to a future period of time. This is extremely useful in accounting for sales trends that occur on non-consistent events such as sporting events, non-calendar specific holidays, promotional events, hurricanes, blizzards, and other types of anomalies that affect petroleum consumption.

2. **Supply and Distribution Optimizer**: This tool is primarily for *optimizing* the distribution segment. The purpose of this tool is to evaluate the different options of transporting the different products to different terminals based on demand forecasts and forward prices so that the margins are maximized. The economic optimization is accomplished by using the Linear Programming technique. The margins calculated include sales revenues as well as the costs of purchase, production, inventory holding, transportation and materials handling. By using its Mixed Integer Programming (MIP) option, the Network Optimizer also permits the user to define variables that can only take on integer values. This capability permits the modeling of the use of whole container or vessels, and a variety of "either/or" situations. The Optimizer input/ output may have a number of maps associated with the model. These maps are used to input data as well as view results. The Distribution Network Optimizer plays a key role in not only making the best use of capacities in the system (asset utilization), but also ensures that all forecast demands are met (prioritizes the distribution to make the most economic sense). There are different means of taking the product from one place to the other. It can be a pipeline, a container, rail wagons, or road tankers. It can also be a combination of two or more means of transportation. The different entities, which comprise the distribution network for the downstream sector, are shown below.

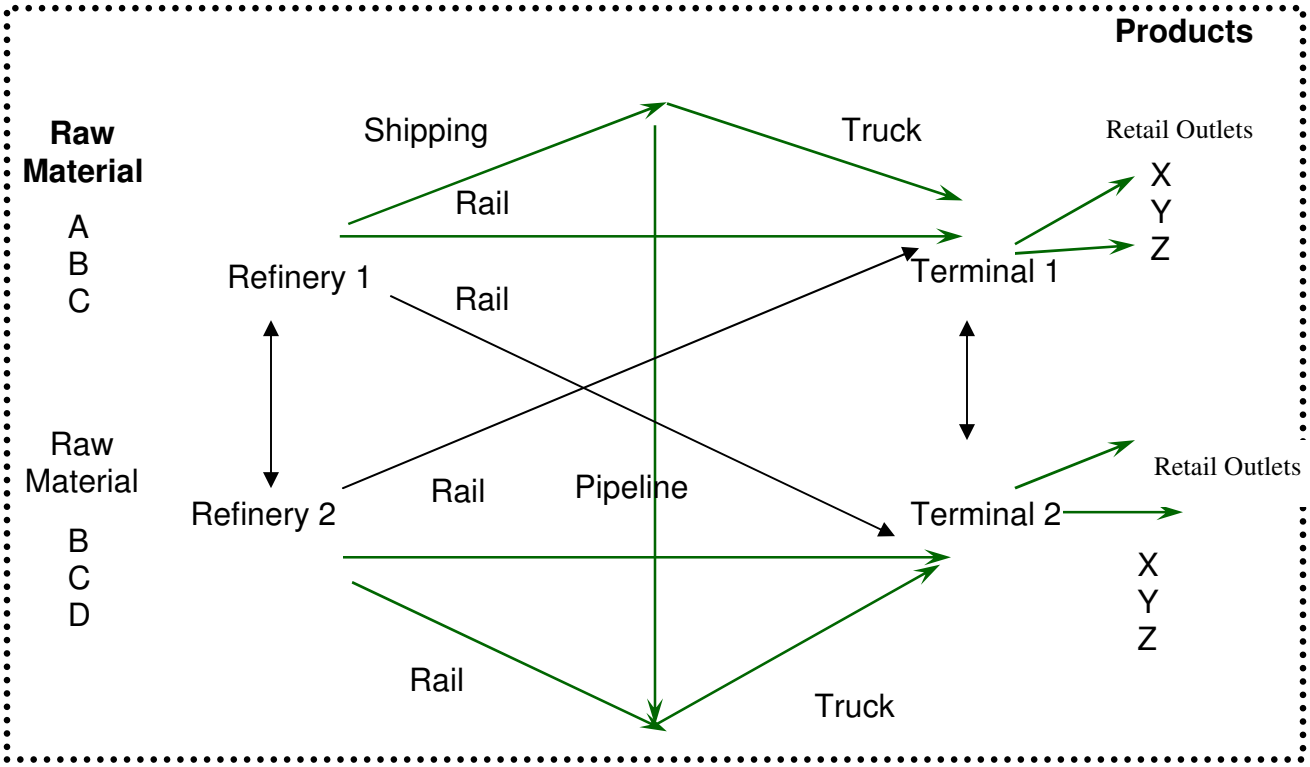

Exhibit C: Supply and distribution options

3. **Replenishment and Scheduling**: The above two steps clarifies how much quantities are to be moved and from where so as to get the optimum routes which would minimize the costs. The important question to be answered now is *when*. There are tools available which work with LPs to arrive at schedules. They use heuristic algorithms that analyze all possible combinations of delivered volumes and available transport to come up with a lowest cost, highest profit solution. These systems determine "delivery windows" rather than simply run out points in order to allow added flexibility for the application to minimize costs and eliminate supply chain failures. By determining both the retain (no-fit) point and the run out point, the Replenishment Scheduling tool gives itself added abilities to evaluate all opportunities before generating the optimized replenishment plan. To generate the optimized plan, the Replenishment Planner utilizes cost minimization and profit maximization heuristics. This replenishment plan considers:
    - Product demand
    - Associated transportation resources and costs
    - Available storage
    - Product acquisition costs, physical constraints and restrictions (Pipeline maximums/minimums, cycle times and product sequences, etc.)
    - Exchange product sources to generate the optimized replenishment plan

    Users can manually create their own movements, trades or exchanges, and lock them into the replenishment plan. Movements are defined by products, product volumes, source location, destination, transportation resource, etc.

In this process, the Scheduler can make necessary changes to the "optimized" plan if there are modifications to the transport schedule, sudden transport unavailability, sequencing delays, compartmentation modifications, etc. Those changes are then sent back to the Replenishment Planner for schedule confirmation. These new actuals trigger a series of automated supply chain

adjustments that can extend up into the refinery and crude selection, if warranted. The end result is a completely integrated, dynamic and self-adjusting supply chain planning and scheduling.

Do the Tools Solve all the Problems?

It would appear that streamlining the entire downstream distribution is just a matter of implementation and integration of the above tools. Most of the available software claim a savings of 6-8% reduction in transportation costs alone by using an integrated package. However, there are issues that are still not resolved as discussed below.

1. A major drawback of the Demand forecasting tools is that they are inward looking and seek answers from history. They ignore the biggest "spoilsport" in any plan that is the competition and their strategies. These need to be countered strategically while taking out the demand numbers.
    - The demand forecasting tools' accuracy is high only over longer periods and this does away the advantage they claim to give for being very responsive to demand fluctuations.

2. The integration of these forecasting tools with the refinery LP is a major issue and many refineries struggle with the online integration of these diverse tools. In most cases, the transfer of data from these tools to LP is manual and hence the optimization across different sets of forecast data is lost.

3. In the supply and distribution optimization, wherein the prices of different products are taken differently for different areas for reflecting the cost of transportation, inputs on correct prices become the key parameter for optimization. Thus, the focus is on estimation of correct prices that can alter the optimization process dramatically.

4. Inputs from POS systems are good and help in managing the stocks in ROs by moving material from the nearest storage terminal. But, there is a disconnect here between whether the movement is as suggested by the forecast and plan, or an unexpected demand. There is a gnawing doubt about whether this was the optimum solution.

5. The issues in integration are different for smaller companies and the oil majors. The smaller companies typically will have specific applications for each function and integrating them is a tough task. The bigger companies have access to all the tools, but have multi-locational plants and a huge number of outlets that result in development of a complex model. Integration of such models with other tools becomes very tough and many times the basics get lost in the complexity.

6. One of the biggest issues in integrating these systems is the swings these data can subject the refinery to. The refineries are not meant to run at different throughputs, severities on a day-to-day basis and "smoothening" of the data by an expert analyst is invariably needed.

Conclusions

- For the entire oil supply chain to move in a single direction, it is necessary to use the tools in demand forecasting, supply and distribution, and replenishment scheduling functions in an integrated manner.
- The optimum performance can only be obtained by integration of not only the above tools but also with the refinery LP and other transaction tracking systems like SAP.
- Since it is very complex to model a multi plant refinery with full details of individual units, it would be a good idea to use different LP models for crude evaluation, planning and for supply and distribution. By different models it is meant that the core model is kept the same and

depending on the end use the complexity of the model is varied. Thus, once the crudes are chosen and forced for the immediate period, a simpler model can be used for integrating with the supply chain. This would help in having a faster convergence time and allow better interpretation of results.

- Strategic inputs from experts in the field are essential in analyzing the inputs before feeding them into a system. These inputs can be in demand numbers to be used for optimization or in generation of forward price for the future.

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