A novel framework and tool for dynamic simulation of Supply Chains

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The supply chain (SC) perspective is the preferred way of operating an enterprise in this era of globalized businesses marked with uncertainties in supply/ demand and tough competition. It is not surprising that most organizations have adopted this viewpoint to manage their supply chains amidst uncertainties that loom large. The effective interaction among the departments of an organization and the external SC entities such as suppliers, third party logistics providers, customers etc. would result in an efficient supply chain. However, the occurrence of exogenous events in the premises of external SC entities (labor strike, accidents) or elsewhere in the globe (terrorist attacks, earthquake, tsunami etc.) can disrupt the day-to-day operations of even an efficient SC. With SCM advocating against the locking of capital in the form of inventories, companies are targeting 'leaner' supply chains with minimal buffers making them more vulnerable to such disruptions.

The dynamics that emerge due to these disruptions may be so complex that they cannot be envisaged unless one has a tool to detect disruptions, determine the course of events and their effects that follow the disruption, and hence a best remedial action. Therefore, the need of the hour is to leverage on the advances in IT and the superior computing power available today to develop a user-friendly tool with innovative modeling that would enable disruption management (Srinivasan et al, 2004), rescheduling, SC reconfiguration etc. The dynamic, non-linear and complex nature of supply chains with information delays, the disparities in SC entities and the desire for integrated decision making suggested a hybrid, multi-prong approach that will necessarily have dynamic simulation as a key component. To this end, an ideal simulation tool for SC studies should imbibe a framework that will allow the user to experiment with and evaluate his/her policies or decisions on the SC in a plug-and-play manner.

In this paper, we present one such dynamic simulation framework for the analysis of supply chains with specific application to a refinery supply chain. We have implemented this framework in a decision support system called Integrated Refinery In Silico (IRIS). The framework has been developed in SIMULINK® that provides graphical user interface for building models as block diagrams using click-and-drag mouse operations. We have modeled all the refinery departments such as sales, procurement, storage, operations, product inventory with their functions such as demand forecasting, procurement planning, tank allocation, production, blending respectively. We have also modeled the suppliers characterized by their supply lead times and the refinery configuration involves SBM pipeline, crude tanks, CDU, reformer, cracker, blend tanks, etc.

The user is provided with the liberty of running the entire simulation by plugging in procurement, scheduling and tank allocation policies for normal operation and emergency procurement and rescheduling policies for abnormal situations. Several realistic features such as ship waiting demurrage, premium payment for emergency crude purchase, etc. have been captured while considering the economics of the refinery SC. We present a few case studies to show the efficacy of IRIS to handle several disruption scenarios such as ship arrival delay, demand changes, product consignment rejection. We also illustrate the capability of IRIS to perform SC design with a case study involving capacity expansion in the refinery tank farm and its economic implications.

IRIS can be an ideal test bed for researchers in the domain of refinery planning and scheduling to test their algorithms much akin to the testing of control architecture on the widely used Tennessee Eastman Problem (Downs and Vogel, 1993). It can also serve as a training aid for novices in a refinery and a pedagogical tool to teach Supply Chain Management. The fact that IRIS has been modeled in SIMULINK®, one of the widely used dynamic simulation packages both in industry and academia, will hold it in good stead in comparison to expensive commercial simulation packages. In short, the flexible and user-friendly features of IRIS in a novel modeling framework with its powerful features would make it a handy tool for refinery SC simulation.

Reference

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