Simulation-Driven Optimization in Supply Chain and Logistics

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Executive Summary: Logistics is an important activity in the Supply chain which involves planning, carrying out and management of goods, services, and information from the point of origin to the point of consumption. To optimize the movement, storage and flow of goods, services, and information inside and outside of the organization, people have used different methods of optimization all of which are interlinked and interdependent to each other. Traditional optimization techniques often fall short of considering all the dynamics of the supply chain and logistics due to which they are not able to predict the future leading to challenging issues in logistics. **Simulation-driven optimization is a way to cope up with these challenges in the supply chain industry. It considers real-world variability to provide more accurate and robust output.**

Introduction

Supply Chain Industry has evolved over the period because of its strategic, dynamic and consumer-driven mechanism. In the last decade, the Supply Chain Industry has integrated itself and became more efficient and enhanced across the entire value chain processes. The widespread usage of ERP (Enterprise Resource Planning), integration with the global markets and technologies with end-to-end (E2E) visibility and agility amalgamate multiple systems that previously were not in communication with each other, ultimately lead to more accurate planning and more efficient production sequences.

The recent development and growth of the E-commerce industry have also played a major role in the transformation of the Supply Chain Industry where the seller no longer requires a shop to display their products. Warehouses are acting as big shops and as the industry is growing they want to increase customer service satisfaction by introducing hassle-free returns, next-day delivery, same-day delivery, product exchange, and other lucrative offers so that more and more people are compelled to shop online. **This fast-paced delivery of goods is not just limited to the e-commerce industry, other industries such as manufacturing, Oil and Gas, Healthcare, Automotive, etc has also observed that the customer expectation is on the rise, for example, *critical drugs need to be supplied on the same day, orders of spares from the Oil rigs need to be delivered ASAP, customizable car buying option, etc.*** Earlier if a courier arrived after 10 days people didn't mind but today such a service can put someone out of the business.

The e-commerce industry is boosting due to the wider internet penetration. This forces more expenditure on Warehousing and Logistics so that they can keep up with the pace of the boosted

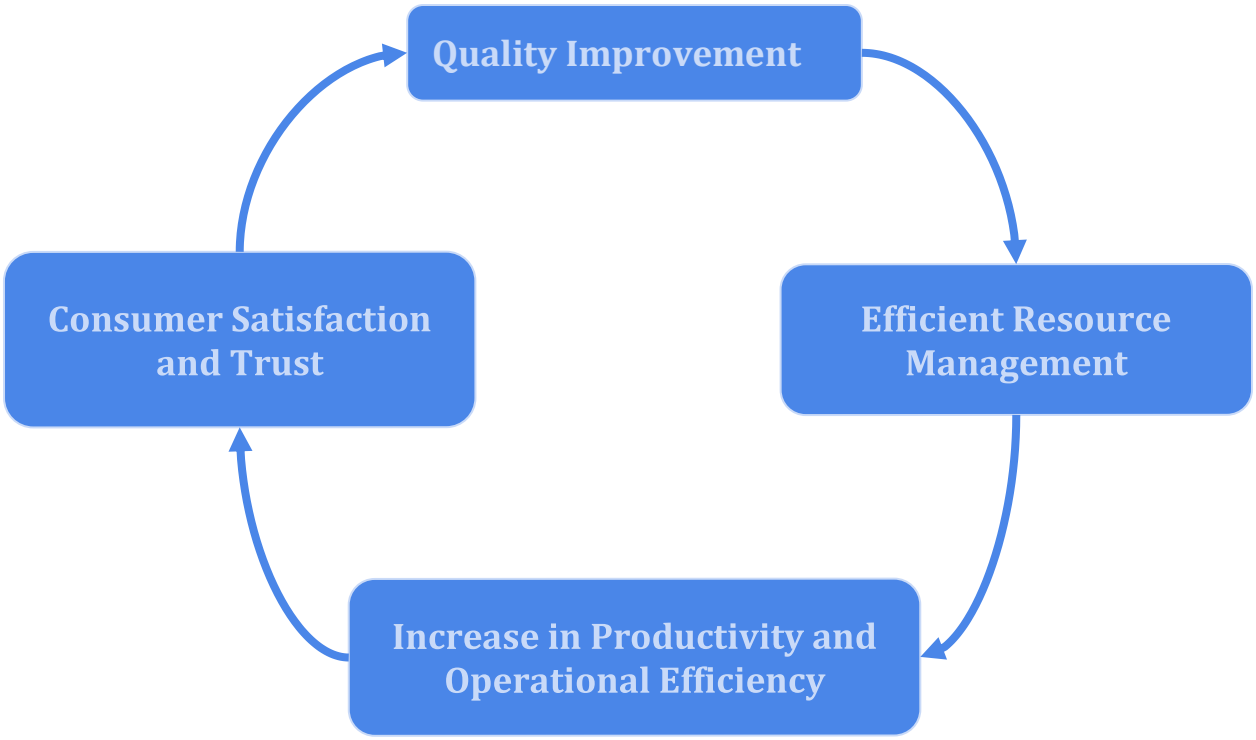
e-commerce industry. There is so much competition in these businesses that supply chains need to be much more efficient to become more profitable. In this global market, people are ordering items from all over the world putting much heavier pressure on transportation making it a major cost factor. To compensate, businesses are trying to reduce costs by utilizing their resources such as warehouse space, fleet, people, etc. in a more efficient manner. **With all these changes there is a requirement of better tools for decision making and to optimize these supply chains on various levels.**

Cost Reduction Techniques

The industry is practicing various techniques to decrease their overhead by optimizing its resource management and operations. Some of these practices include the following:

- **Centre of Gravity Analysis** for finding potential warehouse locations,
- **Logistics Network Optimization** for selecting the right number of warehouses out of the potential list,
- **Vehicle Route Optimization** for minimizing transportation costs and maximizing vehicle utilization,
- **Inventory Optimization** for better utilization of warehouses,
- **Warehouse Pick distance optimization** for better productivity in the warehouse,
- **Optimization of shipping cost** by reducing the volumetric weight of the shipping carton,
- **Demand forecasting** for better planning of inbounds,
- **Dashboarding** for keeping a track of various processes and their productivities in the warehouse, etc.

Apart from these standard practices, scientists and practitioners are also exploring alternative approaches through Operations Research augmented with Machine Learning techniques to reduce cost and increase efficiency in the business.



Problems faced by Supply Chain Industry

It has been observed that the effectiveness of these standard techniques is often limited leading to the less than desired level of resource management due to unfiltered wastage of resources. These techniques are often implemented in a sequence due to which the solution to one problem often leads to a different problem in unrelated processes in the system, which is mostly unavoidable in processes which are not independent of the rest of the system. The prime example of this comes from a case of Vehicle routing Optimization where routes that are optimal in theory might not prove to be so due to exclusion of the factors like the number of dock doors or the number of outbound gates at the warehouse in the formulation of the optimization problem. If a solution is suggesting that all trucks leave together and the gate processing time is 15 minutes then a queue will be created at the gate delaying most of the trucks by more than an hour. This delay can potentially make the suggested optimal solution to lead the system into a more severe state at times full of chaos. Therefore, **the process needs to be optimized in such a way that it takes these dynamic events, such as changing customer demand patterns, variable lead times, variable replenishment time, etc., into consideration to some extent while giving the solution.**

These problems are actually resolvable through traditional **discrete optimization techniques** through the utilization of simulations that are closely modeled based on historical data and validated by the operations experts of the targeted environment.

> ***Simulation*** *is a technique where the behaviour of the system and its processes are closely replicated in a simulated environment so that the impact of the changes in the processes can be simulated in that virtual environment without affecting the live environment of the system. A simulation of a particular process will take into consideration all the variations that can happen and shows how different models behave in various scenarios by testing them in a virtual environment before observing an adverse event on the ground.*

This enables the operation research scientists to avoid most of the derivative impact to the system occurring from their solutions.

General Steps in Simulation

1. Gather data of the system and its processes and analyze it to replicate them in the simulation model.

2. Model various processes along with their processing times as well as the process flow logics encompassing all of the system elements.

3. Validate this model with historical data, experiments, and expert opinions of the operations department leading to a validated model that should replicate the issues in the current operations.

4. The above model is further studied to address the issues in the current operations and to make sure that solutions are addressing these issues without raising new concerns in the system or its processes.

5. The viable solutions from the above model can be further validated through controlled experiments in the real environment under the supervision of the experts controlling the operations of the targeted system.

Various Use Cases of Simulation-Driven Optimization

Simulation, in general, can be used in various circumstances like **Process Redesigning to study the impacts, Queuing problems, Future Resource Requirement, Combinatorial process optimization, etc.** Some of the use cases and problem statements are discussed below.

Optimizing Gate Congestion: The welcome center of warehouses with fixed queuing capacity can lead to penalty charges when the imposed limits are crossed. The problem can be addressed by optimizing the number of gate counters required to control the queuing under imposed limits. The processing time of the trucks may also vary according to their type and purpose. The time and the arrivals may also follow some patterns or probability distribution. Considering all of these parameters and more one can develop a discrete optimization problem that can be solved to arrive at the desired result. But simulation can reveal factors like people's constraints such as their restricted availability of 5 days a week and them requiring two consecutive off-days.

Yard Space Optimization: Resource management for a warehouse yard operation such as the required units of parking spaces, yard tractors, number of inbounds and outbound gates number of inbound and outbound docks, etc. can be determined using simulation performed based on business constraints. Further, simulation can also help you study future yard space requirements. A forecast of a 10% increase in business year on year can even put a strain on the existing resources and simulation can identify these chokepoints well in advance.

Airline Scheduling: Airlines generally operate on a fixed schedule. Consider an airline warehouse that receives the food carts from the inbound flight and then processes and replenishes them before sending them to the outgoing flights. Under the requirement of carts to be processed immediately at the arrival of the flights, the requirement of people at the warehouse varies based on the flight schedule. Simulation-driven optimization can help in streamline the resource requirement in the warehouse for each shift such that the schedules are met.

Inventory Optimization: The inventory optimization for the cases where the demand and replenishment time varies at high frequency is often more complex in the non-simulated case. The simulation-driven optimization decreases the complexity of this optimization problem by a high margin revealing optimal inventory policy for individual items at a faster pace.

Conclusion

Optimization techniques help in the decision making processes of the Supply Chain Industry but are prone to produce optimal results in the localized environments which are not stable and often lead to adverse impacts on other processes of the system. Simulation is a way to validate the models and to reveal the things that are not captured in the solutions generated by traditional optimization methods. Supply Chain Industry is very dynamic in nature and it faces challenges every now and then. One cannot say that using simulation-driven optimization all the existing problems in the supply chain can be solved, still, its effectiveness cannot be questioned. It is an effective tool and a value add for the operations providing them with more controlled resource handling and robust planning. Simulation-driven optimization can give the much-required edge to address the nuances of the operations which the traditional techniques are falling short in addressing.