NORTHEASTERN UNIVERSITY

School of Engineering

MECHANICAL & INDUSTRIAL ENGINEERING DEPARTMENT

IE7200 Supply Chain Engineering

1st Partial Exam Project

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Introduction to Supply Chain Management

The process of turning raw materials into a final product by businesses through a network of processes is called the supply chain. Each node in a supply chain represents different stages of the process in most cases a particular company or business goes through a series of stages that involves production, sourcing of raw materials, and transforming these raw materials into finished products that later can be transported and delivered to the consumer. For a material to be converted to a finished product there are many stages of production, numerous deliveries from suppliers to the manufacturing centers, assembly warehouse, and distribution centers. A supply chain helps in mapping out every stage in the most effective way and reaching the consumers.

Figure 1. Supply chain stages

Supply management plays a pivotal role in modern business, particularly in the context of a globalized economy where supply chains often stretch across various countries and continents. A proper and well-orchestrated supply chain can help in organizing the flow of resources and can also help in yield a multitude of substantial advantages in cost reduction, customer satisfaction, market competitiveness.

In general Supply chain management is not the only aspect on which business organization function or operate, but its strategic imperative is what that yield substantial cost saving customer satisfaction market agility and competive advantage. In todays interconnected and globalized routes of business and systemic progression supply chain is considered to be significant and cannot be overstated.

Introduction to Push/Pull System

1. Push System

   When the products are pushed via a channel from the production of the product to the retailers, also means that the production happens based on the demand forecast. The Push system becomes beneficial when there is high demand for the product and then a large inventory of the product to meet the customer demand.

2. Pull System

   It's a demand-driven supply chain management, where goods/products are produced based on the demand or the amount and time needed. It is also often used when there is a limited demand for the product in the market. At times pull systems are implemented in situations where the cost of maintaining the excess inventory exceeds the cost of having the product in surplus in the inventory.

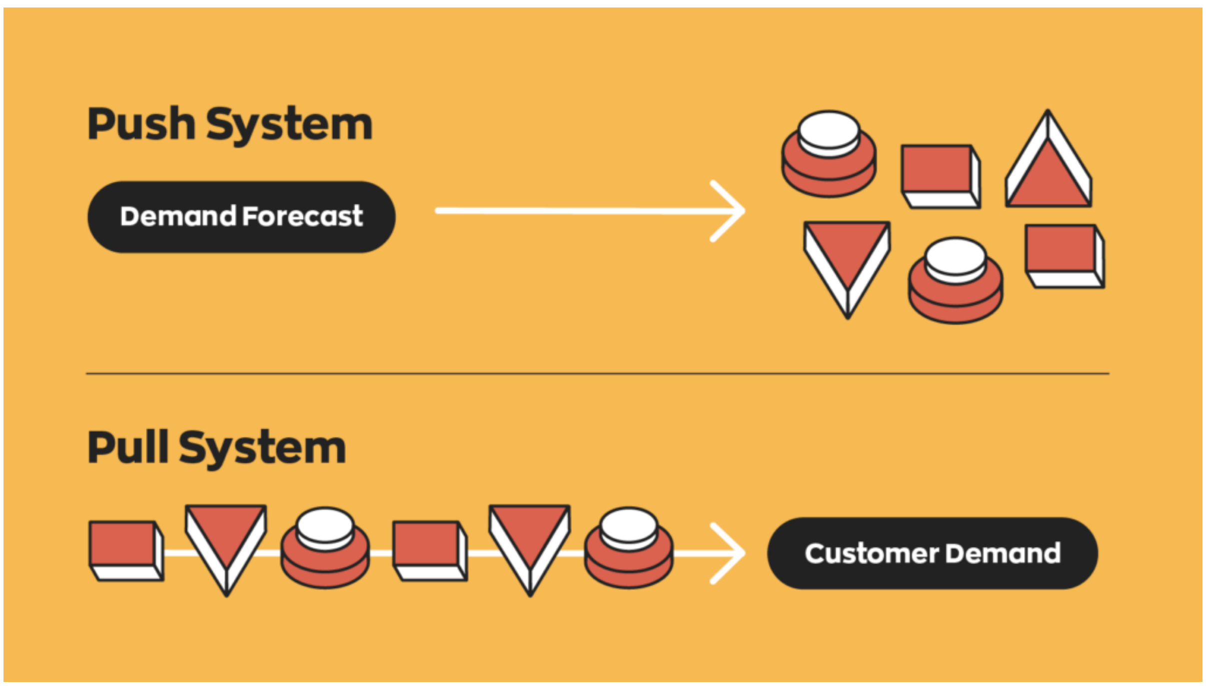


Figure 2. An illustration of the push-pull method of the supply chain

The hybrid push/pull systems of the model are usually applied in the high-tech industry where there is a larger number of stock held which exceeds the scope of the model. A push-based supply chain is mostly based on demand that has been or is expected. Whereas is pull-based supply chain is mostly based when there is a demand for a particular product/part. With the right implementation of the push-pull systems, companies can significantly improve their overall operations and lower manufacturing costs paving the way for better profit and sustainability.

System Dynamics of Hybrid push/pull model:

The hybrid push Push/Pull system described in Figure 3 consolidates both push and pull systems within the supply chain in such a manner, that the push system is integrated into the upstream and the pull system is integrated into the downstream. This model has been referenced from Stermans 2000 stock management model, which incorporated financial performance structures for a comprehensive performance measurement. This particular model was chosen because of its ability to capture complex behaviors that are observed in real-life supply chains, making this a suitable foundation that helps deeply in understanding inventory management dynamics. This particular hybrid push/pull model specifically investigates the inventory process involved in two automobile companies in Nigeria, showing us how these companies model and navigate the challenges of balancing orders and maintaining inventory to fulfill customer demand.

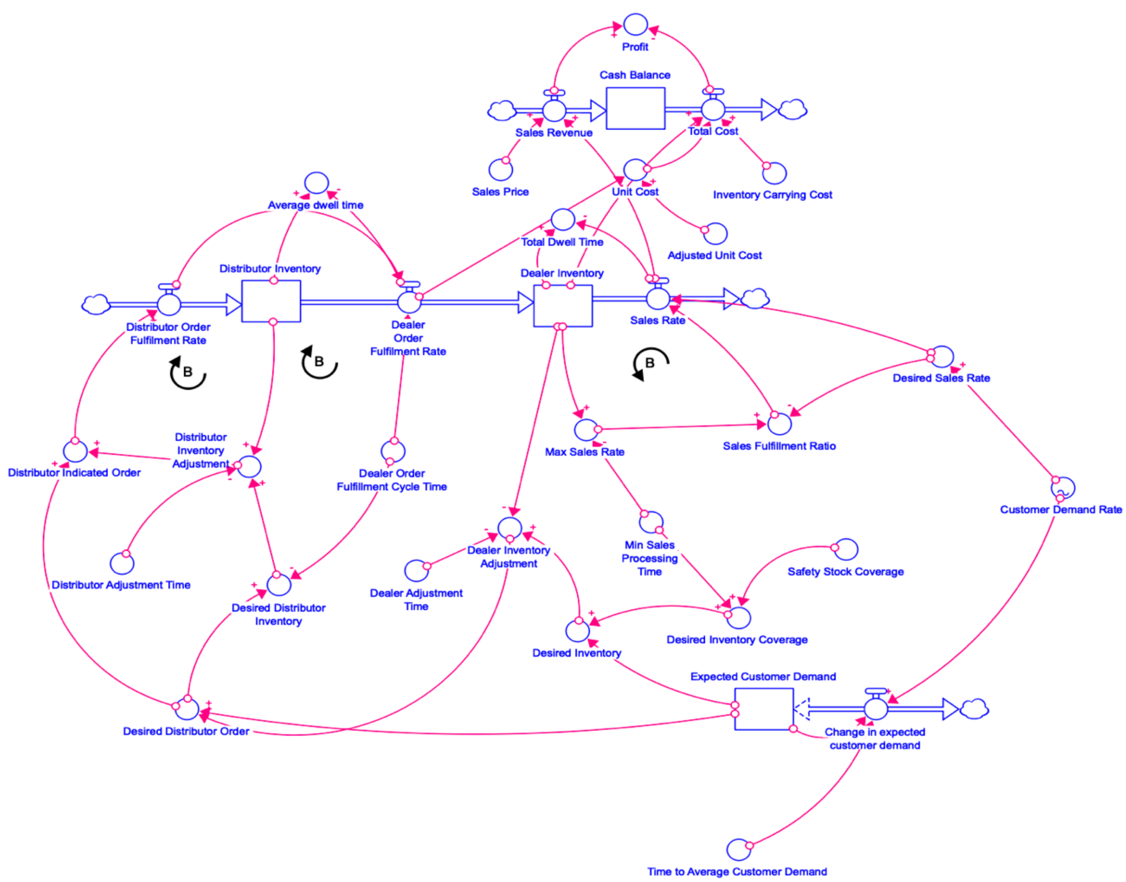


Figure 3. The hybrid push/pull model (modified from Sterman 2000 PG 768) was recreated in STELLA Architect software iss Exchange.

In this model, the distributor's inventory undergoes a two-phase cycle. Initially, it increases as the distributor places orders with the manufacturer/importer (upstream partners), extending beyond the model's scope. Subsequently, the distributor's inventory decreases as it fulfills orders from dealers. On the other hand, the dealer's inventory experiences a similar two-phase cycle. It increases upon receiving fulfilled orders from the distributor and decreases based on the sales rate. The smoothing of customer demand is heavily reliant on the sales rate to end customers. The model incorporates various variables and parameters that capture the intricate relationships between customer demands, dealer desired inventory levels, order fulfillment rates, distributor order fulfillment rates, distributor desired inventory levels, and the time required to achieve these desired inventory levels. The decision rules of the model align with those of a push system, providing a foundation for a valid comparison with push-only models.

The dynamics of the inventory management model illustrate the interconnectedness of the supply chain elements, demonstrating how decisions at each stage influence the overall performance. The complexities lie in the relationships between distributor and dealer inventories, order fulfillment rates, and responsiveness to customer demand. By focusing on the push/pull dynamics in the context of the automotive industry in Nigeria, this model aims to offer insights into how companies manage their inventories while striving to maintain a delicate balance between meeting customer demands and optimizing operational efficiency. The adaptation of Sterman's model enhances the model's realism and provides a robust platform for a meaningful comparison between push and hybrid push/pull systems.

Hybrid push/pull model Case study A: Business as Usual (BAU)

Case study A is a solely owned Nigerian company with businesses and interests all over the Nigerian economy that include engineering, foods, automobiles, beverages, medical, information technology, and agriculture. The company partners with globally respected companies with an iconic brand portfolio, the company is still at present considered by the people of Nigeria as a major dealer of automobile products and a positive contributor to Nigeria's economy.

The parameter values used for the analysis of the hybrid push/pull model case A and formulas are mentioned in the Appendix table. We are taking Business as usual condition.

The model is run for 130 weeks, and the model output is portrayed in different graphs as shown below. The customer demand rate is taken as business as usual as shown in the figure. It is worth emphasizing the differences in model behavior in terms of distributor inventory, dealer inventory, distributor order fulfillment rate, dealer order fulfillment rate, and sales rate in the output graphs.

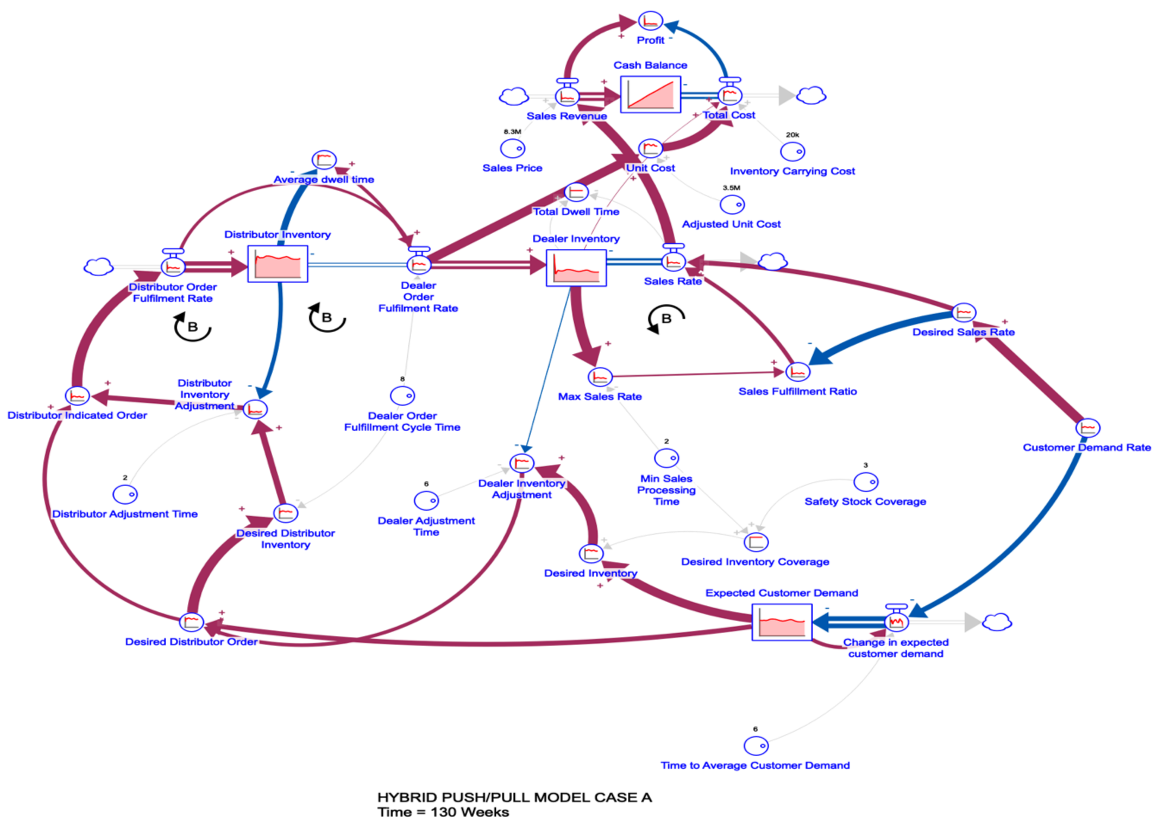


Figure 4. Hybrid push/pull model simulation for case a (BAU)

The customer demand pattern used in this case presented in Figure 5 is unpredictable. Customer demand drops to 109 at week 10 this trend continues fluctuating until the end of the simulation time of 128 units/week at week 130. A smoothing function is enabled to represent the expectations of managers concerning customer demand. The objective of this test is to further validate the model, as well as analyze the model response towards changes in demand and how it affects the distributor inventory, dealer inventory, sales rate, etc.

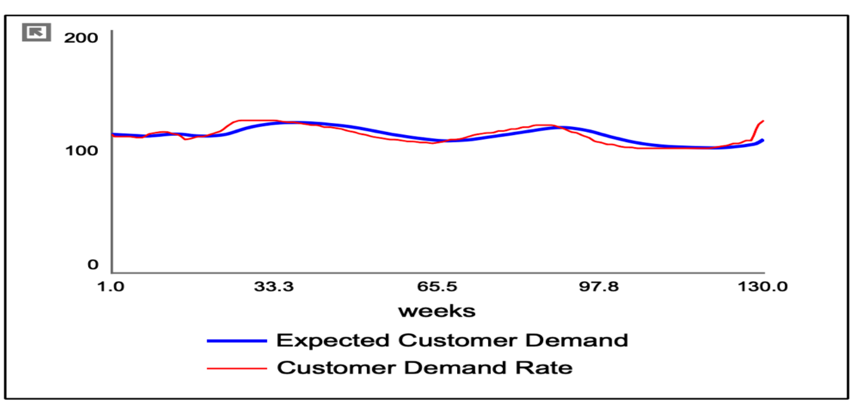
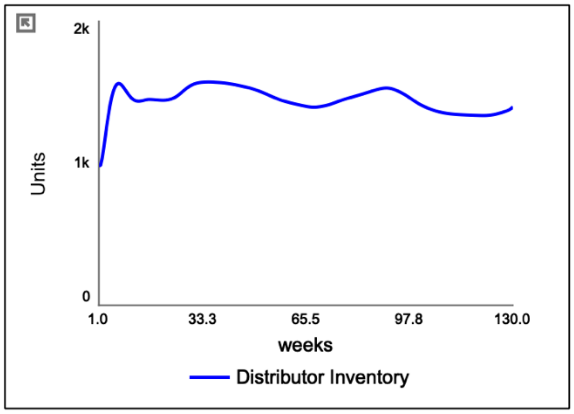
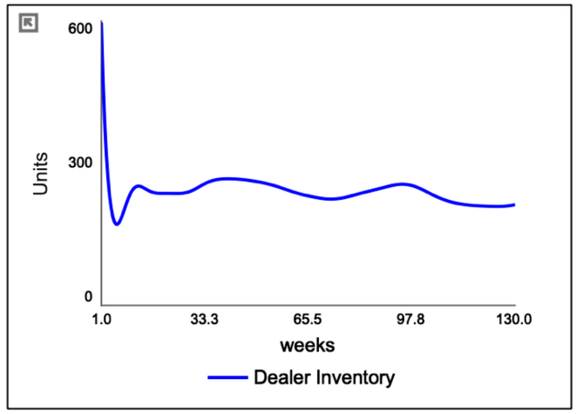


Figure 5. Graph showing expected and customer demand rates.

The results from the simulation run for the hybrid push/pull model in the business-as-usual demand pattern are shown in Figures 6a and 6b. The fluctuations in the distributor inventory and dealer inventory continue throughout the period with this demand pattern because of delays in fulfilling orders. The fluctuations and instabilities in the inventory level are severe throughout the simulation in both graphs. Both distributor and dealer inventory are affected by the expected customer demand rate.





Figures. 6a and 6b

The hybrid push/pull model incorporates features from both push and pull models, resulting in increased oscillations during the simulation. The transition between push and pull phases introduces a delay in inventory adjustments, significantly impacting three crucial factors: distributor order fulfillment rate, dealer order fulfillment rate, and sales rate. Figure 7 illustrates the inflow and outflow, both falling below the inventory level. These delays have a substantial effect on dealer and distributor inventory, causing a decline in order fulfillment rates and sales rates as the delays lead to an extended dealer order fulfillment cycle.

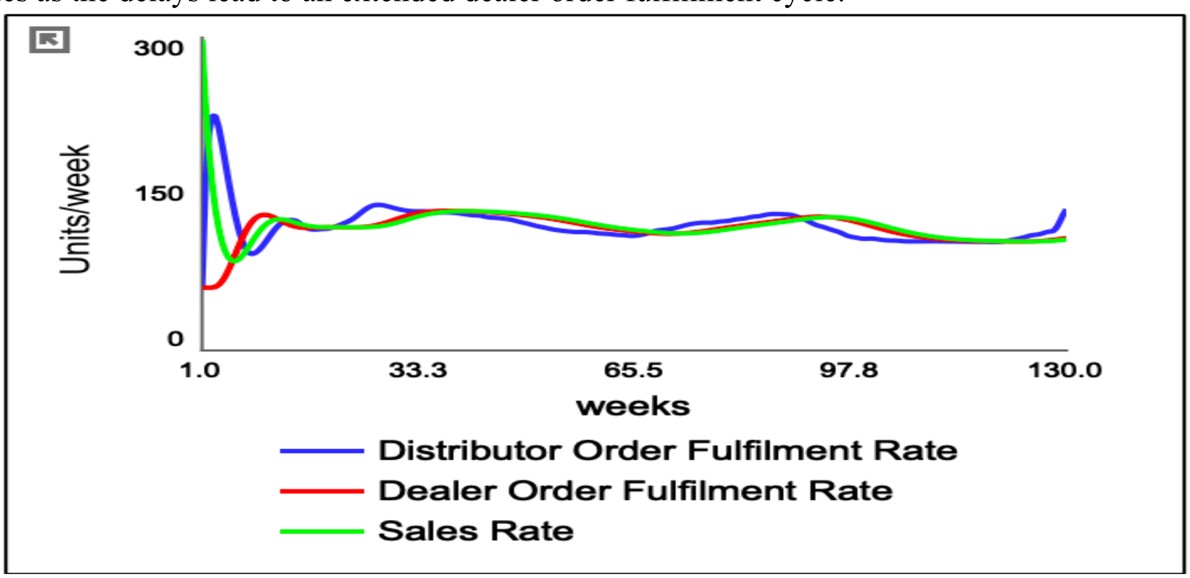


Figure. 7 Effects of BAU demand on Inflow and outflow under hybrid push/pull model

Figure 8 provides a visual representation of profit depreciation and the rising cash balance over the 130-week simulation period. In the initial week, the company generated a gross profit of 1.39 billion NGN, but by the 7^{TH} week, the profit fell to 385 million NGN. At last, in the 130th week, the profit was 500 million NGN. This decline is primarily attributed to delays in dealer and distributor order fulfillment rates, leading to a significant increase in inventory carrying costs and overall expenses, consequently reducing profits over time.
The graph illustrating the cash balance clearly shows a continuous increase over the 130 weeks. This upward trend is mainly driven by factors such as capital costs, company-owned assets, and the profit generated by the company. The profitable nature of the company contributes to the consistent growth of its cash balance until the point where the company starts incurring losses.

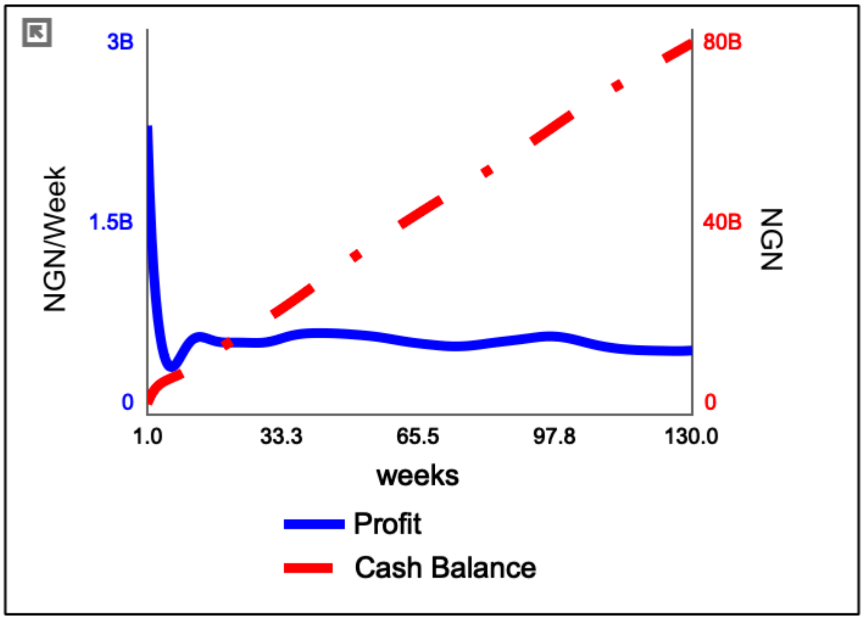


Figure. 8 Effects of BAU demand on profit and cash balance under hybrid push/pull model

Hybrid push/pull model Case study B: Business as Usual (BAU)

Case Study B operates as a smaller automotive product dealer in Nigeria. Specializing in Toyota cars, the company not only sells vehicles but also distributes spare parts to other automobile dealers on a smaller scale. Their marketing emphasizes a commitment to delivering cost-effective and reliable vehicles that go beyond customer expectations. The company aims to exceed customer satisfaction by offering reasonably priced and guaranteed products, ensuring affordability and fairness in their pricing strategy.

The parameter values used for the analysis of the hybrid push/pull model case A and formulas are mentioned in the Appendix table. We are taking Business as usual condition.

The model is run for 110 weeks, and the model output is portrayed in different graphs as shown below. The customer demand rate is taken as business as usual as shown in the figure. It is worth emphasizing the differences in model behavior in terms of distributor inventory, dealer inventory, distributor order fulfillment rate, dealer order fulfillment rate, and sales rate in the output graphs.

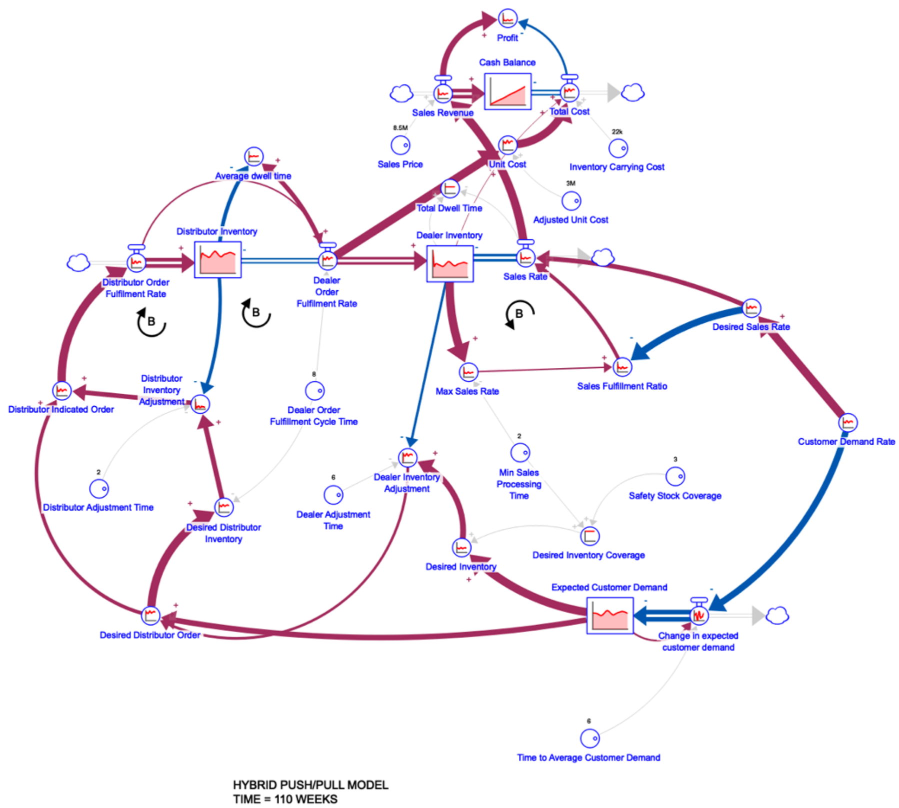


Figure. 9 HYBRID PUSH/PULL MODEL SIMULATION FOR CASE B (BAU)

The customer demand pattern used in this case presented in Figure. 10 is predictable. The initial demand is at 18 units/week; this demand then decreases to 14 at week 20 this trend continues fluctuating until the end of the simulation of 15 units/week at week 110.

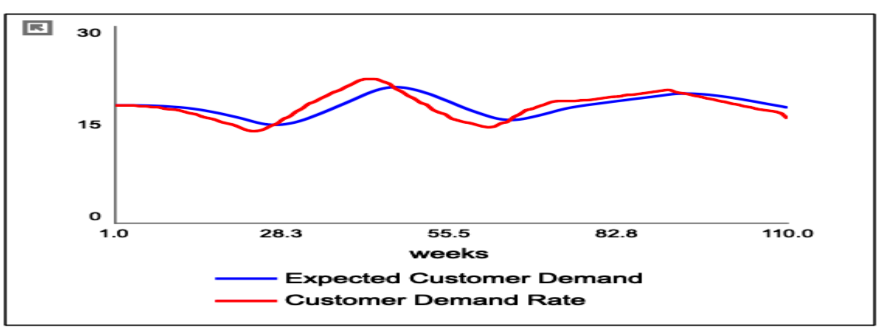
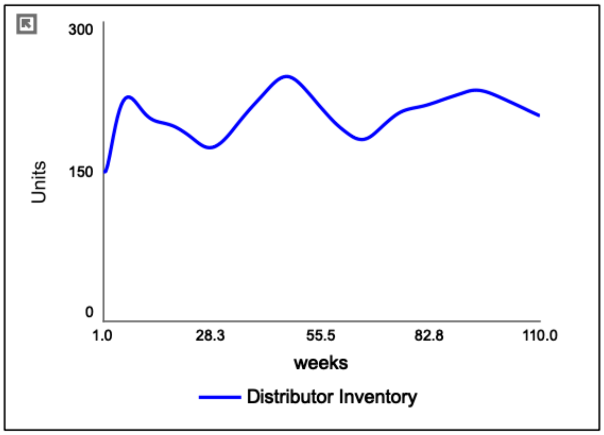
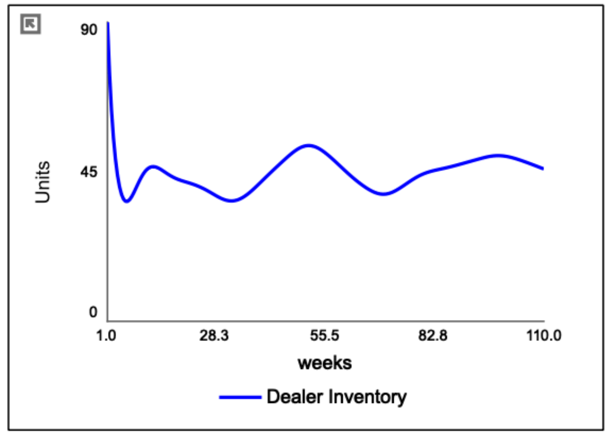


Figure. 10 Graph showing expected and customer demand rates.

The results from the simulation run for the hybrid push/pull model in the business-as-usual demand pattern are shown in Figures. 11a and 11b. The fluctuations in the distributor inventory and dealer inventory continue throughout the period with this demand pattern because of delays in fulfilling orders. The fluctuations and instabilities in the inventory level are severe throughout the simulation in both graphs. Both distributor and dealer inventory are affected by the expected customer demand rate.





Figures. 11a and 11b

The transition between push and pull phases introduces a delay in inventory adjustments, significantly impacting three crucial factors: distributor order fulfillment rate, dealer order fulfillment rate, and sales rate. Figure 12 illustrates the inflow and outflow, both falling below the inventory level. These delays have a substantial effect on dealer and distributor inventory, causing a decline in order fulfillment rates and sales rates as the delays lead to an extended dealer order fulfillment cycle. But at the end of the 110th week, the outflow of all three parameters is almost the same with a very slight difference.

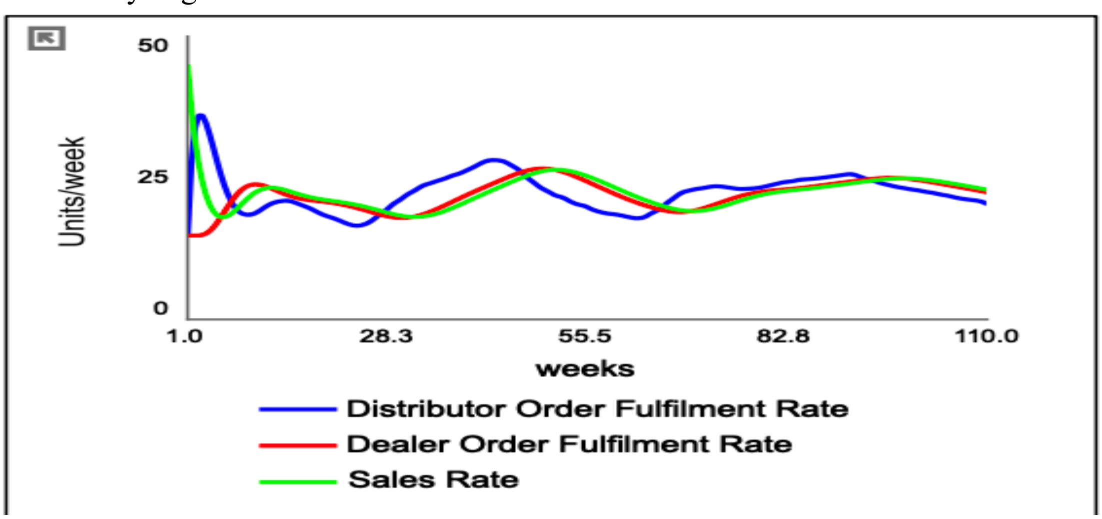


Figure. 12 Effects of BAU demand on inflow and outflow under hybrid push/pull model

Figure. 13 provides a visual representation of profit depreciation and the rising cash balance over the 110-week simulation period. In the initial week, the company's profit fell to almost 100 million

NGN but by the 130th week, the profit was stabilized at 130 million NGN. This decline is primarily attributed to delays in dealer and distributor order fulfillment rates, leading to a significant increase in inventory carrying costs and overall expenses, consequently reducing profits over time.
The graph illustrating the cash balance clearly shows a continuous increase over the 130 weeks. This upward trend is mainly driven by factors such as capital costs, company-owned assets, and the profit generated by the company. The profitable nature of the company contributes to the consistent growth of its cash balance until the point where the company starts incurring losses.

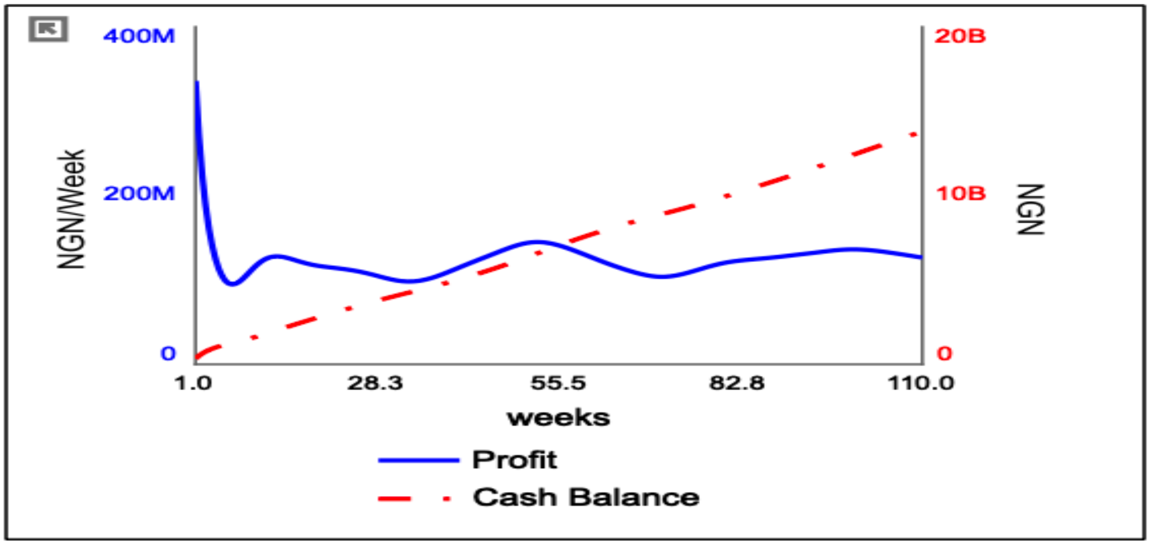


Figure. 13 Effects of BAU demand on profit and cash balance under hybrid push/pull model.

Scenarios to be analyzed (Sensitivity Analysis):

Scenario 1:
In the current analysis, we are focusing on Safety Stock Coverage within the context of two scenarios, Case A and Case B. Safety stock coverage in supply chain management refers to the surplus inventory held by a company as a precautionary measure to mitigate the risk of stockouts or disruptions in the supply chain. This surplus acts as a buffer to accommodate uncertainties in demand, supply chain delays, or unexpected fluctuations in production or consumption.

The primary objective of maintaining safety stock is to ensure that a company can effectively fulfill customer demand even in unpredictable or challenging circumstances. It serves as a cushion to absorb variations in both demand and supply, playing a crucial role in preventing stockouts and upholding customer satisfaction. The measure of safety stock coverage is commonly expressed in terms of the duration, such as the number of days or weeks, that the additional inventory can sustain normal operations.
For both Case A and Case B, the safety stock coverage is initially set at 3 and dealer order fulfillment cycle time is at 8. To explore various scenarios related to dealer inventory, distributor inventory, total cost, and sales revenue, we will specifically focus on Case A. In this analysis, we will systematically adjust the safety stock coverage from 3 to 1.5 for three consecutive run cycles and set dealer order fulfillment cycle time from 8 to 4 This deliberate variation is undertaken to

observe the impact on different aspects, including dealer and distributor inventory levels, total cost implications, and sales revenue, as we modify the safety stock coverage.

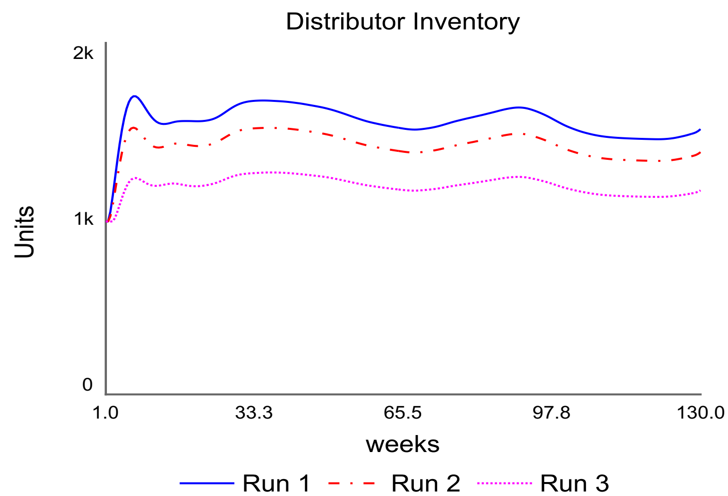


Figure. 14 Distributor inventory when SSC & DEOFCT changed.

Figure 14 reveals a stable increment among the three scenarios. Interestingly, Run 1 is greater than Run 2. Run 1 has a safety stock coverage of 1.5. In comparison to Run 3, Run 1 indicates a higher value, suggesting that a reduction in SSC and DEOFCT directly corresponds to an increase in distributor inventory.

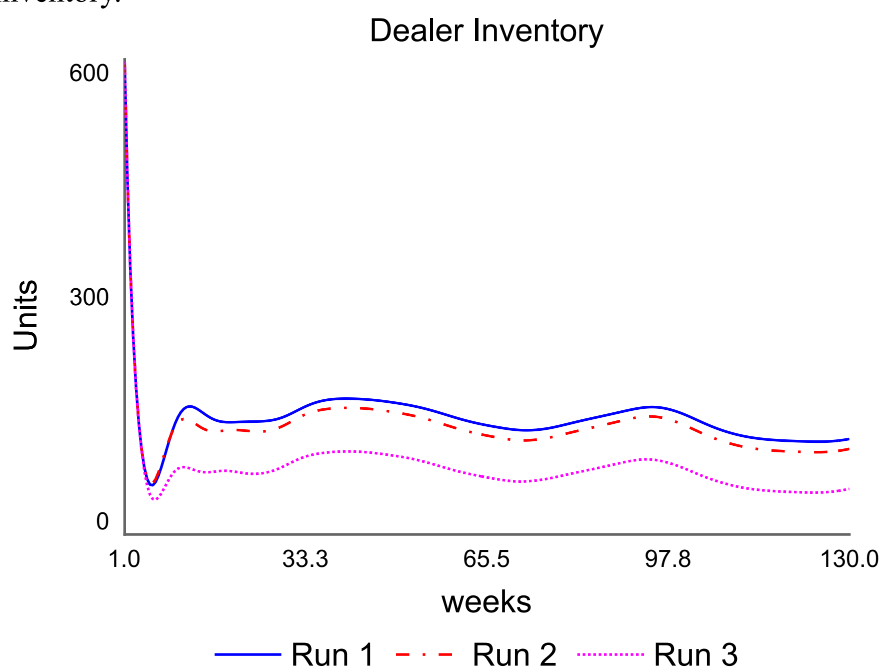


Figure. 15 Dealer inventory when SSC & DEOFCT changed.

Figure. 15 illustrates three distinct scenarios depicting the impact of safety stock coverage on the model. In Run 1, where the safety stock coverage is set at 1.5, the dealer inventory is notably higher compared to Run 2. Conversely, in Run 3, which exhibits the lowest number of units among the three scenarios, the safety stock coverage is 3. This observation implies that a decrease in safety stock coverage corresponds to an increase in dealer inventory.

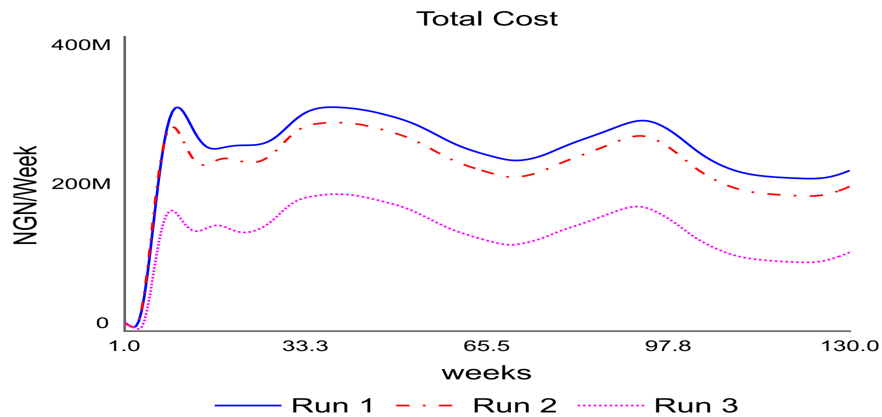


Figure. 16 Total costs when SSC & DEOFCT changed.

Figure 16 illustrates a noticeable trend where a decrease in safety stock coverage correlates with an increase in total cost. Specifically, at a safety stock coverage of 1.5, the total cost value appears to have nearly doubled the initial value observed at a safety stock coverage of 3.

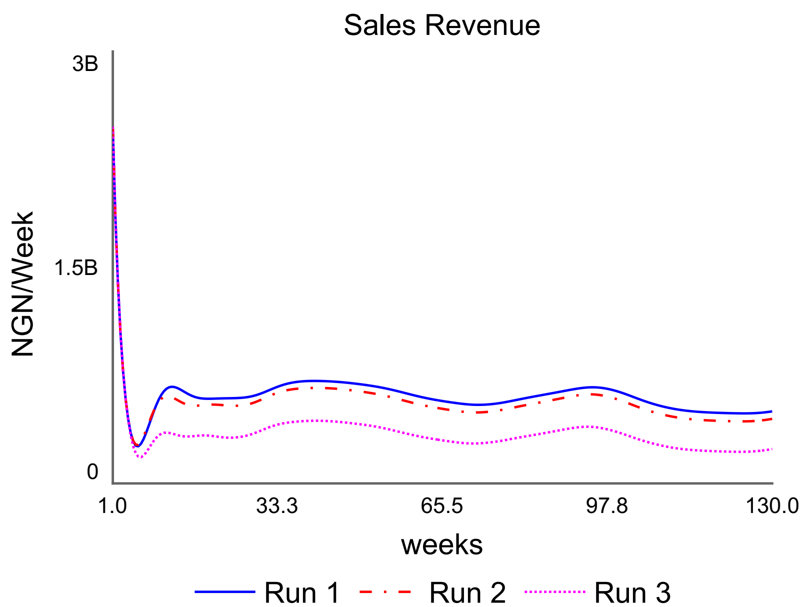


Figure. 17 Sales Revenue when SSC & DEOFCT changed.

The trend observed in Figure 17 aligns with the previous Figure 16, although the specific numerical values differ. The consistent pattern indicates that as safety stock coverage decreases, there is a corresponding increase in sales revenue.

The acquired results reveal an inverse correlation between dealer inventory and distributor inventory. As the cycle time and safety stock coverage decrease, dealer inventory experiences a reduction. This observed trend can be attributed to the initial minimal stock held by the dealer at the cycle's outset, placing pressure on the distributor to maintain inventory levels to meet the dealer's fluctuating demands.

The decrease in safety stock coverage prompts a reduction in the dealer's inventory as per their stock plan. Consequently, the dealer needs stocks from the distributor at a higher rate or more frequently than in the initial scenario. Simultaneously, the reduction in the dealer order fulfillment cycle time eases the burden on the dealer to uphold excess inventory, thanks to a significantly shortened lead time for obtaining stocks from the distributor. This facilitates a quicker ordering and replenishment process for the dealer.

While the lower inventory level contributes to a decrease in the total incurred cost, the necessity for the dealer to maintain safety stock, coupled with reduced inventory levels, may pose challenges in meeting customer demands as effectively as before. Table 1 provides a comprehensive summary of the values obtained after sensitivity analysis, offering a clearer comparison (Run for a time horizon of 130 weeks).

Table 1:

Parameter Values	SSC = 3 & DEOFCT = 8	SSC = 1.5 & DEOFCT = 4
Distributor Inventory	1160	1510
Dealer Inventory	57.5	121
Total Cost	107M	218M
Sales Revenue	239M	500M

Table 1: Summary of Sensitivity Analysis for Scenario 1

Scenario 2:

Consider Case Study B, where we aim to reduce the dealer order fulfillment cycle time from 8 to 5.3 and safety stock coverage from 3 to 1.5. Like Scenario 1 we will conduct sensitivity analysis on Scenario 2. Here, Case B is run for 110 weeks.

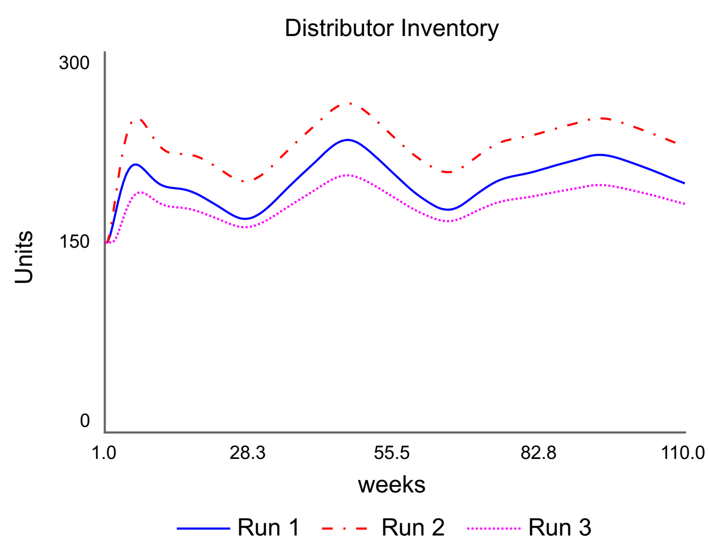


Figure. 18 Distributor Inventory When SSC & DEOFCT changed.

In Figure. 18 we can see that Run 2 has the highest distributor inventory value when the SSC & DEOFCT is between the range provided. The run 2 values lie between 3 to 1.5 for SSC and 8 to 5.3 for DEOFCT.

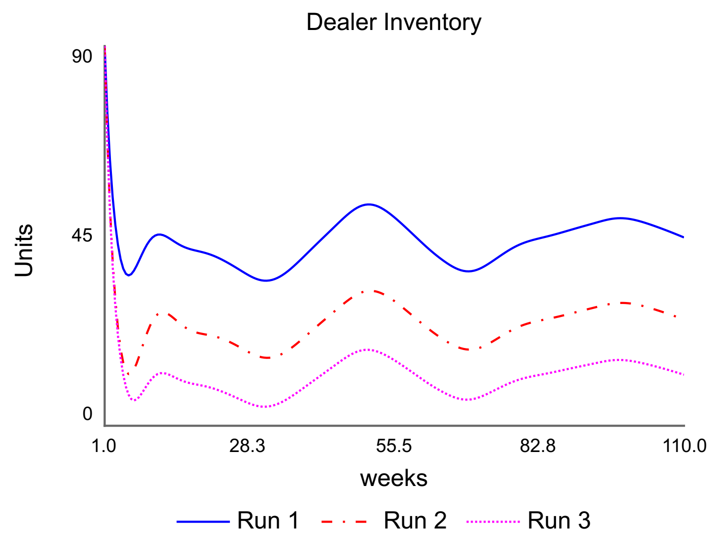


Figure. 19 Dealer Inventory When SSC & DEOFCT changed.

In Figure 19, a clear observation is that as both safety stock coverage (SSC) and dealer order fulfillment cycle time (DEOFCT) decrease, there is a concurrent increase in dealer inventory.

Figure. 20 Sales Revenue When SSC & DEOFCT changed.

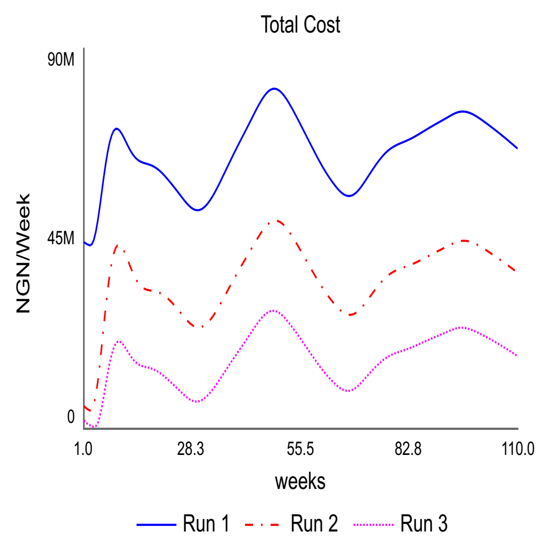


Figure. 21 Total Cost When SSC & DEOFCT changed.

Likewise, in both Figure 20 and Figure 21, a parallel trend is evident, wherein the reduction of safety stock coverage (SSC) and dealer order fulfillment cycle time (DEOFCT) corresponds to an increase in total cost and a decrease in sales revenue.

Table 2 contains the numbers for the sensitivity analysis for changed parameters.
Table 2 Final values at the end of 110 weeks.

Parameter Values	SSC = 3 & DEOFCT = 8	SSC = 1.5 & DEOFCT = 5.3
Distributor Inventory	180	197
Dealer Inventory	12.1	44.1
Total Cost	17.2M	66.4M
Sales Revenue	51.4M	190M

Table 2: Summary of Sensitivity Analysis for Scenario 2

The trends observed in Scenario 1 and Scenario 2 remain consistent when altering the safety stock coverage and dealer order fulfillment cycle time. Scenario 1 corresponds to Case A, while Scenario 2 represents Case B, with adjustments made to the parameters accordingly in each scenario.

Conclusion

An evaluation of two automotive supply chain networks, differing in scale, was performed using Stella Architect software. Both networks employ a push system upstream and a pull system downstream, with a primary focus on understanding how customer demand affects the preparedness of entities within the supply chain. The influence of customer demand on distributor and dealer inventory was found to be variable, particularly for matured organizations operating in intermediate product life cycle stages, where demand displays fluctuating patterns.

In both Case A and Case B, dealer and distributor inventory showcased similar patterns, with distributor inventory levels consistently leading compared to dealer inventory levels, attributed to lead times between dealers and distributors. Despite encountering challenges in adapting to abrupt changes in customer demand, the push-pull hybrid system effectively managed extreme inventory values resulting from these variations.

A sensitivity analysis was conducted to identify parameters significantly Impacting Inventory levels and financials. It was revealed that reducing safety stock coverage time and dealer order fulfillment cycle time enhances system agility to respond to changes. However, despite the observed reduction in total cost, the organization’s profit also decreased. In such a scenario, the distributor needs to maintain a higher stock level to meet the dealer’s requirements due to the reduced cycle time and higher order fulfillment rate.

Accessing STELLA:

The STELLA files are uploaded on Google Drive. The files can be accessed by clicking on the hyperlinks below.

Case A: File

Case B: File

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Appendix

I. **Adjusted Unit Price** Adjusted pricing per units as a function of customer variations and situational contexts.

II. **Customer demand**: The major external supply-changing factor that influences the supply chain and is a mix of different demand scenarios such as normal businesses mixed with optimistic and pessimistic scenarios.

III. **Dealer Adjustment Time**: The amount of time it takes a dealer to get their inventory in order with the company's desired level.

IV. **Dealer Inventory Adjustment**: Dealer takes up/ reduces a position for fine-tuning the mix with respect to inventory position and customers' demand.

V. **Dealer Order Fulfilment Cycle Time**: The average time between the start and end of a dealer's order

VI. **Dealer Order Fulfilment Rate**: It is defined as the average delay of the dealer's order fulfilment rate, which is computed by the time between a dealer's order and its fulfilment.

VII. **Dealer Safety Stock Coverage**: Number of weeks of stock held by the dealer above nominal processing time to account for uncertainties in 20inimized demand.

VIII. **Demand Cycles**: These show the availability of demand variations over time, which play a significant role in the company's inventory levels.

IX. **Desired Dealer Inventory**: The desired stock level to maintain – forecasting customer demand 2. The customer order 10. Stay-or-Quit Inventory: The stock level where profit is 20inimized if it is kept. If more inventory is ordered, profits can increase – but this is only up to a point.

X. **Desired Dealer Inventory Coverage**: This is the number of weeks of inventory a dealer sets to have in stock to correspond with demand forecasts.

XI. **Desired Distributor Inventory**: which is calculated based on estimated customer demand.

XII. **Desired Distributor Order**: Indicate the quantity figure that the customer typically demands for the product being sold.

XIII. **Desired Push Rate**: the amount of volume you want pushed through your supply chain.

XIV. **Desired Sales Rate** : This is equal to customer demand, as there is no final inventory to sell; it also assumes no backlog of unfilled orders.

XV. **Distributor Inventory Adjustment Time**: the time required for the distributor to adjust its inventory to the desired level.

XVI. **Distributor Indicated Order**: Equivalent to the des-ired rate of distributor order fulfil-ment.

XVII. **Distributor Inventory**: It reflects the quantity of stock held at a distributor to fill orders from dealers, dependent on its percentage of fulfilled orders.

XVIII. **Distributor Inventory Adjustment**: Corrections done by the distributor to his inventory to accommodate the desired stock levels.

XIX. **Distributor Order Fulfilment Rate**: Represents the distributor indicated order rate, constrained to be non-negative

XX. **Expected Customer Demand**: A vision of projected demand, considering the foreseeable lag in assessing changes in actual demand.

XXI. **Final Time**: This marks the end period for the simulation model.

XXII. **Initial Time**: This is the starting point of the simulation model.

XXIII. **Inventory Carrying Cost**: includes the costs involved in keeping an item on the shelf, usually expressed as a percentage of the value of an item.

XXIV. **Max Sales Rate** It is the sales rate that will be achieved when the current inventory position is reached and the minimum time for processing sales has been allowed for.

XXV. **Min Sales Processing Time**: The minimum amount of time by the dealer is necessary to process and sell products.

XXVI. **Profit**: It is a measure of the actual monetary gain that is obtained when the revenue from the sale of goods and services exceeds the incurred costs and expenses of operating the enterprise.

XXVII. **Sales Fulfilment Ratio**: This is a ratio expressing to what extent sales have been achieved versus the levels desired. If sales are high, then the ratio will also be high.

XXVIII. **Sales Price**: the price at which vehicles are sold to customers (including discounts).

XXIX. **Sales Rate**: It shows the required sales ratio for a company after adjusting sales fulfillment rate.

XXX. **Sales Revenue**: This is the total amount of money obtained from sale of vehicles to customers.

XXXI. **Saveper**: The frequency of storing output data during simulation is defined by this variable.

XXXII. **Time Step**: These are discreet time intervals used in the simulation model.

XXXIII. **Total Cost**: It refers to all costs incurred before selling a product, which include inventory purchases and carrying costs.

XXXIV. **Total Dwell Time**: This implies how long it takes the dealer to meet customer demand requirements.

XXXV. **Unit Cost**: This represents the cost involved in holding and selling one car unit.

Parameter	Value
Distributor Adjustment Time	2
Deaker Adjustment Time	6
Dealer Order Fulfillment Cycle Time	8
Minimum Sales Processing Time	2
Safety Stock Coverage	3
Time to Average Customer Demand	6

Table 3: Parameters used for simulation for Scenario 1 and 2

Case A	Value
Inventory Carrying Cost	22,000
Sales Price	8,500,000
Adjusted Unit Cost	3,000,000

Table 4: Financial Parameters for Scenario 1

Case B	Value
Inventory Carrying Cost	20,000
Sales Price	8,300,000
Adjusted Unit Cost	3,500,000

Table 5: Financial Parameters for scenario 2

Title	Equation
Unit Cost	Adjusted Unit Price * Dealer Order Fulfilment Rate
Total Dwell Time	ZIDZ (Dealer Inventory, Sales Rate)
Total Cost	Unit Cost + (Inventory Carrying Cost*Dealer Inventory)
Sales Rate	Desired Sales Rate * Sales Fulfilment Ratio
Sales Revenue	Sales Rate * Sales Price
Sales Fulfilment Ratio	ZIDZ (Max Sales Rate, Desired Sales Rate)
Profit	Sales Revenue-Total Cost
Max Sales Rate	Dealer Inventory/Min Sales Processing Time
Expected Customer Demand	SMOOTH (Customer Demand Rate, Time to Average Customer Demand)
Distributor Order Fulfilment Rate	MAX (0, Distributor Indicated Order)
Distributor Inventory Adjustment	(Desired Distributor Inventory-Distributor Inventory)/Distributor Adjustment Time
Distributor Inventory	INTEG (Distributor Order Fulfilment Rate - Dealer Order Fulfilment Rate)
Distributor Indicated Order	Distributor Inventory Adjustment + Desired Distributor Order
Desired Sales Rate	Customer Demand Rate
Desired Distributor Order	MAX (0, Expected Customer Demand + Dealer Inventory Adjustment)
Desired Distributor Inventory	Dealer Order Fulfilment Cycle Time * Desired Distributor Order

Desired Dealer Inventory Coverage	Min Sales Processing Time + Dealer Safety Stock Coverage
Desired Dealer Inventory	Expected Customer Demand * Desired Dealer Inventory Coverage
Dealer Order Fulfilment Rate	DELAY3 (Distributor Order Fulfilment Rate, Dealer Order Fulfilment Cycle Time)
Dealer Inventory Adjustment	(Desired Dealer Inventory-Dealer Inventory)/Dealer Adjustment Time
Dealer Inventory	INTEG (Dealer Order Fulfilment Rate-Sales Rate, Desired Dealer Inventory)
Average Dwell Time	ZIDZ (Distributor Inventory, Dealer Order Fulfilment Rate)
Cash Balance	INTEG (Sales Revenue-Total Cost)

Table 6: Stock formulas for hybrid push and pull.