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Smart logistics and efficient supply chain for discrete industry

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Abstract: Natural calamities have had an impact on manufacturing and logistics operations. Manufacturers, merchants, suppliers, shopkeepers, wholesalers, and others have been subjected to limitations, which have had an influence on the demand and supply of various commodities. Natural calamities such as earthquakes, tsunamis, floods, and draughts, as well as man-made disruptions such as strikes, terrorism, political disturbance, emergency, and external aggregation, have far-reaching consequences for all sorts of units in all sectors.
This study builds a simulation model of the truck parts distribution system network, using three different scenarios to show disruption in the automotive parts supply chain and logistics. It has become increasingly challenging to manage supply and demand over a large network of distribution system networks because to the changing environment, which includes the increased effect of natural catastrophes and man-made disruption. This paper also highlights the need of an efficient supply chain and smart logistics in the automobile sector in the face of diseases, pandemics, and natural calamities.
Keywords: Supply chain management, Warehouse optimization, lead time.

I. INTRODUCTION

Natural catastrophes and man-made disasters may cause supply chain interruption. Several events in the past, such as the Gujarat earthquake in 2001, the Tsunami in Japan in 2011, the Indian Ocean earthquake and tsunami in 2004, and the outbreak of various strikes, terrorism, political unrest, and emergency external aggregation, have all resulted in a global tragedy, affecting not only human life but also economic activities such as manufacturing operations, supply chain and logistics, and a variety of other sectors. The automotive, tourism, aviation, energy, construction, telecommunications, food, and healthcare industries have all been badly disrupted by these sorts of disruptions.

There are several spare components that are utilised in the manufacture or assembly of vehicle assemblies. Various components or accessories are in buffer stock for vehicle production or assembly. This form of production has a significant requirement for inventory. There are around 5000 to 7000 pieces for assembly or vehicle manufacture in total. Such essential or complete components are usually available for delivery from various parts or towns throughout the nation. However, pandemics such as COVID-19, as well as natural disasters such as floods and earthquakes, have a significant influence on transportation and manufacturing operations, causing manufacturing and production activities to cease and the inventory process to be severely disrupted. We can't handle such a highly demanded lead time to process inventory or various sections of the vehicle or accessories due to the rise in lead time. There are about 20% of key spare components that assist in the fabrication of 80% of output, which is required for efficient manufacturing. Pareto analysis is the name for this procedure.

[1] **Stephan Kreipl, et al. (2004) -** highlights several planning and scheduling models, such as lot sizing and machine scheduling. In the next section, it categorises sectors that need supply chain planning and scheduling. Then comes a thorough overview of how supply chain planning and scheduling models may be utilised to build decision support systems. [3] **Rajendra Kumar Shukla, et al.(2011**) suggested managers research why, what, and how they should manage supply chains. It studied the concept of logistics management and the need for SCM from an enterprise's standpoint. This helps managers who are interested in supply chain management. [4] **R.Caridad, et al. (2017**) Continental Mabor's raw-material warehouses were the focus of a case study. The goal of the project was to adopt bin management and analyse the consequences and changes that would occur as a result. Aside from building a new warehouse, the old one was reorganised to eliminate the requirement for external storage.[10] **Sanjay Choudhary,et al.(2021)** The suggested strategy centred on the utilisation of regional warehouses at the hubs of incoming and outgoing supply nodes, such that several regional warehouses can meet the needs of different assembly units at a consistent pace and without fail.[15] **Rui Lv, Linfu Sun , et al.(2016)**created a parallel GA based on the MapReduce computing platform.Using parallel GA,

a three-level distributed spare parts warehouse allocation method was solved. [16] **Seval Ene, et al. (2012**In the automobile sector, a newly created mathematical model and stochastic evolutionary optimization technique were used to construct a storage assignment and order picking system.

In this paper,a simulation model is proposed that may aid in the development of a responsive and robust car component supply chain to meet various sorts of demand and give decision-making assistance for vehicle redistribution and trip restriction in certain locations. This concept aids in the reduction of lead times for vehicle components supply from manufacturers to distribution sites.

II. METHODOLOGY

To reduce delivery time or lead time, we have to setup a central warehouse near the delivery point. When a pandemic and disruption occur, the routes of the delivery of automobile spare parts from the different warehouses to the delivery point are highly affected. The delivery time or lead time is increasing due to this type of disruption and manufacturing processes for automobile spare parts are getting slow as compared to normal scenarios. So, in this case, to maintain or to reduce delivery time, we manage or deliver the demandable or required spare parts from the help of a central warehouse which is present near the delivery point within the required time. So, to set up a central warehouse and load and unload processes, and order assembly processes, with the help of anylogic simulation software, we have to build a model of a warehouse which operates these functions more efficiently.

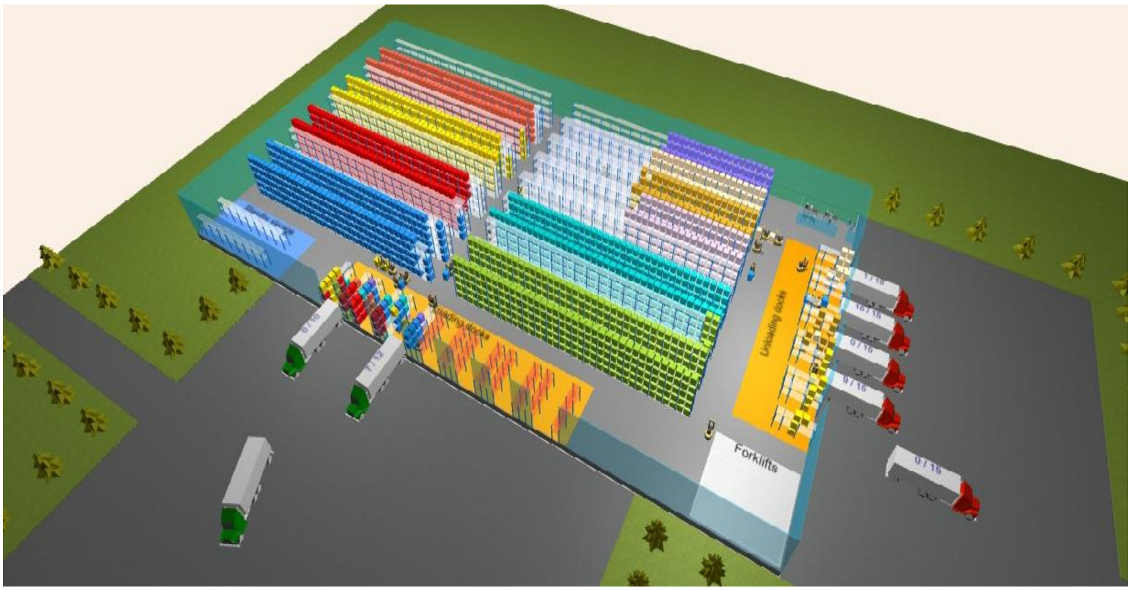


Figure 1: Central Warehouse

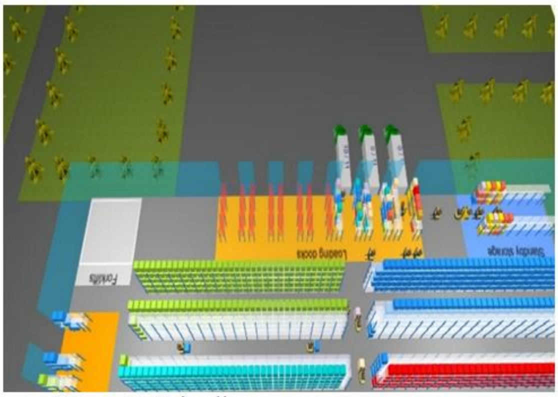


Figure 2: Unloading zone

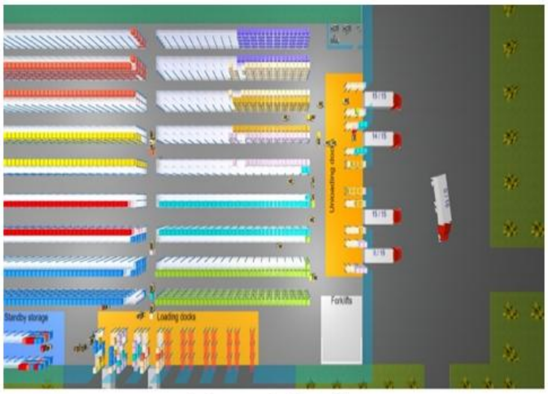


Figure 3: Loading zone

In this central warehouse, we are focused on maintaining the stock of those critical automobile spare parts that are responsible for 80% of the manufacturing processes, and no manufacturing processes are affected during disruption due to the unavailability of automobile spare parts.

2.2 Simulation model of automobile spare parts distribution systems during disruption:

During interruptions or disturbances caused by a range of factors, such as natural catastrophes and man-made events like strikes, political unrest, and so on. As a consequence of travel restrictions and labour constraints created by all of the aforementioned factors, the distribution system and transportation labels face a number of challenges. This study investigates the failure of supply and logistics from network system facilities owing to huge disruption, which leads to further challenges in fulfilling demand at the warehouse end.

The data was obtained from a number of warehouses throughout India. Historical data and warehouse delivery dates are used to calculate the delivery dates of different vehicle spare parts from various manufacturing hubs to various warehouses throughout India.

Each item is supplied to a central warehouse from three different warehouses, ensuring efficient supply and logistics to meet demand. However, due to the disruption, that delivery time is insufficient to meet demand or is unavailable at that moment. The lead time is increasing day by day as a consequence of the disturbances. As a consequence, the model includes two central warehouses (CW), three state warehouses (SW), and six district level warehouses. Three distinct kinds of vehicles, each with varying capacities and speeds, were used. Trucks 1 (low capacity, medium speed), 2 (high capacity, medium to low speed), and 3 (high capacity, medium to low speed) are examples (very high capacity and high speed).

Pareto analysis is used to identify certain crucial portions in the proposed simulation model, and these vital parts are subsequently dispersed using ABC analysis among several truck delivery systems. During a power outage, the auto replacement parts delivery system ensures that these important supplies are available. Several assumptions were made in order to conduct this study, including deterministic demand for these automobile spare parts, the use of a minimum to maximum stock level at warehouses, and unlimited supply from central houses, as well as the assumption that transportation activities are not disrupted. Earlier this year, Stuart and Ivanov created a Framework for assessing risk and disruption in the humanitarian supply chain, based on a dynamic system that includes vehicle replacement parts and other supplies to beneficiaries.

It provided a variety of simulation methodologies for coping with the problem's inherent uncertainty. As a consequence, any logistics software has been utilised to replicate the supply chain disruption model that has been proposed.

The problem in question was simulated. Over the course of two to four weeks, many situations are tested. This simulation includes three scenarios to demonstrate the impact of natural disasters and other disruptions on the supply chain network, as described below:

Scenario 1: There are no disruptions in the vehicle spare parts network system.
Scenario 2: Delivery time during a plant shutdown caused by a disruption.
Scenario 3: Provide a backup facility to ensure that the required service level is maintained in the case of an outage.

These created scenarios are characterised by various events in the simulation model, as indicated. Backup warehouses were first shut off since the country's automotive spare parts distribution network was operating normally, as seen in the diagram. The occurrence of disruption has been recognised in the area of cw1 and identified as the disputed zone due to the high intensity of the disrupted region. Operational and logistical problems have occurred in impacted areas or zones due to labour sortage or inventory. The figure depicts a suspension as the probability of its occurrence approaches 1 in the third row. The backup facility must be activated to satisfy the objective demand, and the probability in the fourth row of simulated occurrences must be changed from 0 to 1 as shown in the diagram.

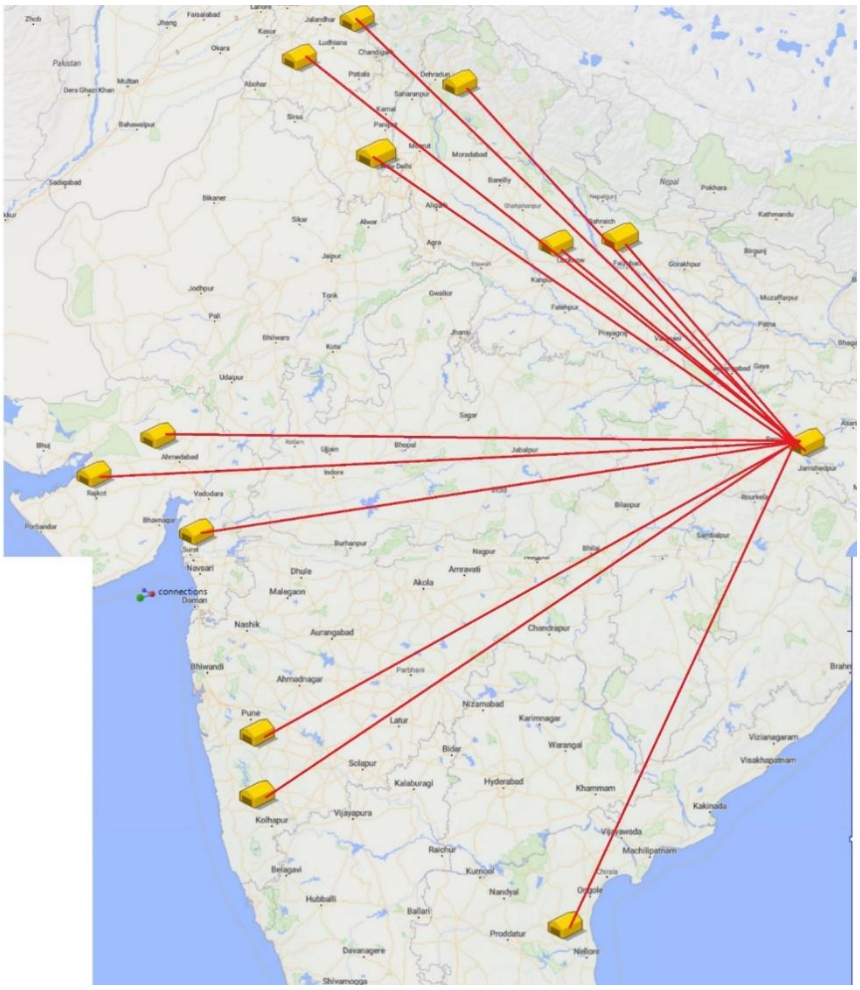


Figure 4: Simulated Network of Distribution system of Automobile spare parts

During the experiment, 10 replications for each scenario were generated, and the impact of different interruptions on the distribution network of car replacement parts in the supply chain was measured in terms of expected lead time (ELT). Maintaining the ELT service level is a top priority for the distribution system network in order to fulfil the demand for this scheme during this difficult era of pandemic and disruption. ELT service level for a product is calculated by using the following formula:

$$ELTSL^{(p)} = \frac{\sum_{k}\sum_{o} D^{p}_{\nabla ko}}{\sum_{k}\sum_{o} D^{p}_{\nabla ko} + \sum_{k}\sum_{o} D^{p}_{\Delta ko}} \quad \forall p$$

Where,
P – Set of products
K – Set of customers
O – Number of total orders
p – Product,
p ∈ P k – Customer,
k ∈ K o – Order, o = 1, ... , O
ELTSL (p) – Expected lead time service level for the product, p
Dp ∇ko – Demand fulfilment of product, p within ELT for an order, o by the customer,
k Dp Δko – Demand is not fulfilled of product,
p within ELT for order, o by the customer, k .

S.No.	Name	Event Type	Parameter	Occurrence Time	Trigger	Probability
1	SimulationStart	Facility state	Site: BU_Facility	1/1/21 12:00 AM		1
2	BackupClose	Facility state	Site: BU_Facility	1/1/21 12:00 AM	Simulation start	1
3	Disruption	Facility state	Site: CW_Facility	15/1/21 12:00 AM		0
4	BackupActivate	Facility state	Site: BU_Facility	20/1/21 12:00 AM	Disruption	0

(a) Scenario 1

S.No.	Name	Event Type	Parameter	Occurrence Time	Trigger	Probability
1	SimulationStart	Facility state	Site: BU_Facility	1/1/21 12:00 AM		1
2	BackupClose	Facility state	Site: BU_Facility	1/1/21 12:00 AM	Simulation start	1
3	Disruption	Facility state	Site: CW_Facility	15/1/21 12:00 AM		1
4	BackupActivate	Facility state	Site: BU_Facility	20/1/21 12:00 AM	Disruption	0

(b) Scenario 2

S.No.	Name	Event Type	Parameter	Occurrence Time	Trigger	Probability
1	SimulationStart	Facility state	Site: BU_Facility	1/1/21 12:00 AM		1
2	BackupClose	Facility state	Site: BU_Facility	1/1/21 12:00 AM	Simulation start	1
3	Disruption	Facility state	Site: CW_Facility	15/1/21 12:00 AM		1
4	BackupActivate	Facility state	Site: BU_Facility	20/1/21 12:00 AM	Disruption	1

(c) Scenario 3

Figure 5: Events occurred during disruption in distribution system network

III. RESULTS AND DISCUSSION

In scenario 1,

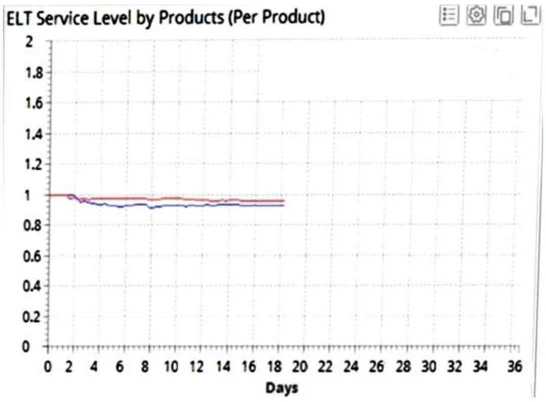
- The ELT service level of automobile parts is 93 percent and 96 percent, as indicated in figure a.
- It shows that under a no-disruption situation, the distribution system network operates with a steady lead time and inventory balance.

In scenario 2,

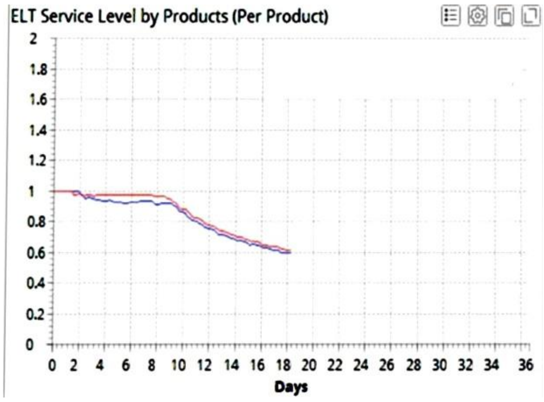
- The number of disputed locations increases, or a disruption happens concurrently in a disputed zone, causing the closure of a central house, as illustrated in figure b.
- The ELT service level of vehicle replacement parts has decreased to 62 percent and 59 percent, respectively.

In scenario 3,

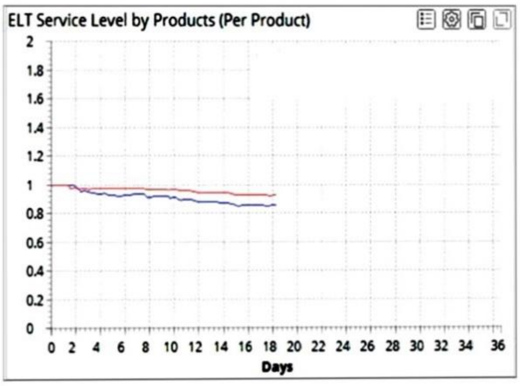
- The ELT service level for vehicle spare parts has been greatly improved with the usage of back of warehouses, as shown in figure c, to 85 percent and 92 percent, respectively.
- Quite downfall is recorded in the ELT service level as compared to scenario 1.



(a) Scenario 1



(b) Scenario 2



(c) Scenario 3

Figure 6: ELT Service level for product A & B

IV. CONCLUSION AND FUTURE WORK

The major reasons of logistics and supply chain delays include natural catastrophes, political issues, strikes, external aggregation, and a number of other obstacles or interruptions. In addition, pandemic and extraordinary case outbreaks have a harmful global influence due to the halting of practically all industrial and logistical activities. This thesis provides a strategy for dealing with interruptions in the supply of car replacement parts, manufacturing components, and other critical commodities caused by pandemics and natural disasters. To access warehouses in highly disrupted areas, the notion of a truck-synchronized distribution system was suggested.

A disruption in the distribution system network's vehicle components for spare parts supply chain was also studied, which happened as a consequence of source warehouses failing to function due to a labour shortfall and a truck driver shortage in impacted areas.

As a consequence, simulated study was conducted by developing three different distribution system network scenarios to highlight the impact of the pandemic on affected areas and the revival strategy. When one of the approved warehouses is unavailable, the findings show that integrating warehouses assists in demand fulfilment from backup warehouses. This thesis investigates scenarios of disturbed areas or destroyed regions by putting a strain on essential supply chain and logistics system functions, notably in the context of an automobile spare parts distribution network.

In future study, a full model of the distribution network of automobile spare parts supply chain and logistics might contain several elements and impediments. Furthermore, mathematical and statistical approaches can be used to deliver rigor-based analysis to capture issues such as automobile spare part supply chains, essential item manufacturing, inventory shortages, and equipment logistics as future scope for this domain's researchers to mitigate pandemic and exceptional case concerns.

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