A Study of Ant Colony Optimization for travelling salesman problem under an effect of Covid-19 pandemic on Medicine Supply Chain inventory management

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Abstract- The impact of the Covid-19 pandemic on the inventory management of the Medicine supply chain is an essential part of inventory management in the area and has become an important concept for the overall profitability of the industrial scenario. It consists of several levels in which the material goes through different phases in order to reach the end customer. The impact of the Covid-19 pandemic on the inventory management of the three-tiered Medicine supply chain includes a Medicine Manufacturing sites, Medicine warehouse and medical centers that bear the costs. A coordinated approach between levels is necessary so that the chain is precisely tuned for the lowest inventory and minimum cost, and therefore, maximum profit. In this article, we consider a three-level coordinated impact of the Covid-19 pandemic on inventory management of the Medicine supply chain with a single Medicine collection point providing a single type of product to distribution centers individual Medicine, then to individual medical centers. A mathematical model is being developed for the coordinated effects of the Covid-19 pandemic on inventory management of the Medicine supply chain, which is solved by using the travelling salesman problem to optimize the ant colony for optimal values of decision variables and target functions. A numerical example is provided and the results obtained here are compared for these techniques.

Keywords:- Inventory, Supply Chain, Medicine Manufacturing sites, Medicine warehouse, medical centers and travelling salesman problem for Ant Colony Optimization

I.   THE EFFECTS OF COVID-19 PANDEMIC ON MEDICINE SUPPLY CHAIN INVENTORY MANAGEMENT NETWORK MODEL OF A REGIONALIZED MEDICINE BANKING SYSTEM

Since the start of the Industrial Revolution, various industries have established business relationships with each other to deal with the challenges of marketing or sales channels. A sales channel that did not contain information about customer demand and requirements resulted in conflicting goals in that channel. Due to a lack of information, there remains a long and unpredictable time to deliver products to customers. Due to disorganization such as fluctuations in the delivery time, quality or quantity of a shipment, it is common for channels to overfill inventory, increasing the cost of channels to meet demand. client. Impact of the Covid-19 pandemic on the Medicine supply chain Inventory management consists of a number of companies that provide items or services to the customer or end user. In other words, the impact of the Covid-19 pandemic on the inventory management of the Medicine supply chain is a network (made up of suppliers, intermediaries, transport and logistics service providers) which represents the flow of raw, semi-finished and finished materials. Products in the direction ahead of the customer while the information and cash flow back. An impact of the Covid-19 pandemic on inventory management in the Medicine supply chain Inventory management (SCM) integrates business processes to provide value-added goods, services and information for customers and others stakeholders. Impact of the Covid-19 pandemic on Medicine supply chain inventory management Inventory management ensures that

customer needs are met by integrating the distribution channels and stages of the impact of the Covid-19 pandemic. 19 on inventory management in the Medicine supply chain. Designing and successfully executing the effects of the Covid-19 pandemic on inventory management of the Medicine supply chain clearly involves effective inventory management of the interactions between channels. In addition, the tendency associated with lean inventory management to reduce inventory levels is leading to an increased reliance between the effects of the Covid-19 pandemic on inventory management partners in the Medicine supply chain. This will increase the risk that the Covid-19 pandemic will impact the inventory management tools in the Medicine supply chain (i.e. suppliers, Medicine draws, customers, etc.). Demand was believed to be a fluctuating function of time and that the backlog of unmet demand was a decreasing function of waiting time. Yadav and Swami (1,3,8) "A model with a partial backlog in production inventory and lot size with time-varying operating costs and female decline". "Integrated supply chain model for material spoilage with linear demand based on inventory in an inaccurate and inflationary environment". "A flexible volume two-stage model with fluctuating demand and inflationary holding costs". Yadav et al. (2,4,5, 9,10,11) "Supply chain inventory model for two warehouses with soft IT optimization". "Multi-objective optimization for the stock model of electronic components and the degradation of double-bearing elements using a genetic algorithm". "An inflation inventory model for spoilage under two storage systems". "Chemical industry supply chain for warehouses with distribution centers using the Artificial Bee Colony algorithm". Management of the supply chain for electronic components of industrial electronics development for warehouses and their environmental impact using the particle swarm optimization algorithm". "Cost method for reliability considerations for the LOFO inventory model with warehouse for chemical industry". Pandey et al. (6) "An analysis of the inventory optimization of the marble industry based on genetic algorithms and particle swarm optimization". Malik et al. (7) "Security mechanism implemented in gateway service providers". Yadav et al. (12,13,14,15,16) "proposed the supply chain management of the National Blood Bank Center for the application of blockchain using a genetic algorithm". "provided drug industry supply chain management for blockchain applications using artificial neural networks". "suggested the red wine industry to manage the supply chain of distribution centers using neural networks". "A supply chain management for the rosé wine industry for storage using a genetic algorithm. "Providing supply chain management for the white wine industry for warehouses using neural networks". Chauhan and Yadav (17,18) "proposed a stock model for commodity spoilage where demand depends on two stocks and stocks using a genetic algorithm". "provide a car inventory system for inflation based on demand and inventory with a two-way distribution center using a genetic algorithm". Yadav et al. (19,20,21,22,23,24) "A method for calculating the reliability of the LIFO stock model with bearings in the chemical industry". "a Ensuring the management of the supply chain of electronic components for the development of the electronics industry in warehouses and the impact on the environment using the particle swarm optimization algorithm". "FIFO in Electrical Component Industry Green Supply Chain Inventory Model with Distribution Centers Using Particle Swarm Optimization". "LIFO in Automotive Components Industry Green Supply Chain Inventory Model with Bearings using Differential Evolution". "FIFO & LIFO in the Industry Green Supply Chain Inventory Model for Hazardous Substance Components with Storage using Simulated Annealing". "Health inventory control systems for blood bank storage with reliability applications using a genetic algorithm". Sana, (25,26) "Price competition between green and non-green products in the context of a socially responsible retail and consumer services business magazine". "An EOQ model for stochastic demand for limited storage capacity". Moghdani et al. (27) "Fuzzy model for economic production quantity with multiple items and multiple deliveries". Haseli et al. (28) "Basic criterion for the multi-criteria decision-making method and its applications". Ameri et al. (29) "Self-assessment of parallel network systems with intuitionistic fuzzy data: a case study". Birjandi et al. (30) "Assessment and selection of the contractor when submitting a tender with incomplete information according to the MCGDM method". Gholami et al. (31) "ABC analysis of clients using axiomatic design and incomplete estimated meaning". Jamali et al. (32) "Hybrid Improved Cuckoo Search Algorithm and Genetic Algorithm to Solve Marko Modulated Demand".

II. MODELLING MEDICINE SUPPLY CHAIN INVENTORY MANAGEMENT

In accordance with the fundamental assumptions, we constrain and define the mathematical model. This mathematical model makes it possible to define the natural world of the cash flow problem linked to the impact of the Covid-19 pandemic on the inventory management of the Medicine supply chain at different levels. These amounts are presented in the form of mathematical concepts and formulated in the model proposed below. A digital representation solves the model using both the travelling salesman problem and the ant colony optimization and compares the results obtained.

The subsequent kind and assumptions are measured for the model.

1. "Deterministic demand".
2. "Instantaneous replenishment rate. Medicine warehouse inventory is an integer multiple of medical canters's inventory".
3. "Medicine manufacturing sites inventory is an integer multiple of Medicine warehouse inventory".
4. "No shortages are allowed".

D=Demand rate in units for each unit time where $D = \left(\dfrac{e^{bT}}{C_{19}} \right)$

$\begin{Bmatrix} MMS \\ \hbar \\ OC \end{Bmatrix}$ =Medicine Manufacturing sites ordering cost $(Rs/order)$ where $\begin{Bmatrix} MMS \\ \hbar \\ OC \end{Bmatrix} = \left(\dfrac{\gamma_0 + 1}{C_{19}} \right)$

$\begin{Bmatrix} MMS \\ \hbar \\ UC \end{Bmatrix}$ =Medicine Manufacturing sites unit cost $(Rs/unit)$ where $\begin{Bmatrix} MMS \\ \hbar \\ UC \end{Bmatrix} = \left(\dfrac{\gamma_1 + 1}{C_{19}} \right)$

$\begin{Bmatrix} MMS \\ \hbar \\ OQ \end{Bmatrix}$ =Replenishment quantity at the Medicine Manufacturing sites in units where $\begin{Bmatrix} MMS \\ \hbar \\ OQ \end{Bmatrix} = \lambda \begin{Bmatrix} MW \\ \hbar \\ OQ \end{Bmatrix}$

$\begin{Bmatrix} MW \\ \hbar \\ OC \end{Bmatrix}$ =Medicine warehouse ordering cost $(Rs/order)$ where $\begin{Bmatrix} MW \\ \hbar \\ OC \end{Bmatrix} = \left(\dfrac{\beta_0 + 1}{C_{19}} \right)$

$\begin{Bmatrix} MW \\ \hbar \\ UC \end{Bmatrix}$ =Medicine warehouse unit cost $(Rs/unit)$ where $\begin{Bmatrix} MW \\ \hbar \\ UC \end{Bmatrix} = \left(\dfrac{\beta_1 + 1}{C_{19}} \right)$

$\begin{Bmatrix} MW \\ \hbar \\ OQ \end{Bmatrix}$ =Medicine warehouse ordering quantity in units where $\begin{Bmatrix} MW \\ \hbar \\ OQ \end{Bmatrix} = \phi \begin{Bmatrix} MC \\ \hbar \\ OQ \end{Bmatrix}$

$\begin{Bmatrix} MC \\ \hbar \\ OC \end{Bmatrix}$ =Medical centers ordering cost $(Rs/order)$ where $\begin{Bmatrix} MC \\ \hbar \\ OC \end{Bmatrix} = \left(\dfrac{\alpha_0 + 1}{C_{19}} \right)$

$\begin{Bmatrix} MC \\ \hbar \\ UC \end{Bmatrix}$ =Medical centers unit cost $(Rs/unit)$ where $\begin{Bmatrix} MC \\ \hbar \\ UC \end{Bmatrix} = \left(\dfrac{\alpha_1 + 1}{C_{19}} \right)$

$\begin{Bmatrix} MC \\ \hbar \\ OQ \end{Bmatrix}$ =Medical centers ordering quantity in units where $\begin{Bmatrix} MC \\ \hbar \\ OQ \end{Bmatrix} = \left(\dfrac{\alpha_2 + 1}{C_{19}} \right)$

ϕ=Medicine warehouse replenishment quantity to Medical centers replenishment quantity.

λ=Medicine Manufacturing Sites replenishmentquantity to Medicine warehouses ordering quantity.

ζ=Carrying charge

θ=Medical centers selling price

TC_{MMS} =The yearly total applicable cost of the Medicine Manufacturing sites

TC_{MW} = The yearly total applicable cost of the Medicine warehouse

TC_{MC} = The yearly total applicable cost of the Medical centers

TC_{MS} = The yearly total applicable cost of the Medicine supply chain

III.   MODEL FORMULATION

3.1 Medical Canters

The applicable total yearly costs of medical centers result from the sum of the yearly ordering and transportation costs of medical centers and can be expressed as:

$$\left\{\begin{matrix} MC \\ \hbar \\ OC \end{matrix}\right\} = \sum_{0}^{T_n}\left(\frac{\alpha_0 + 1}{C_{19}}\right)$$

$$\left\{\begin{matrix} MC \\ \hbar \\ UC \end{matrix}\right\} = \sum_{0}^{T_n}\left(\frac{\alpha_1 + 1}{C_{19}}\right)$$

$$\left\{\begin{matrix} MC \\ \hbar \\ OQ \end{matrix}\right\} = \sum_{0}^{T_n}\left(\frac{\alpha_2 + 1}{C_{19}}\right)$$

$$TC_{MC} = \frac{\left\{\begin{matrix} MC \\ \hbar \\ OC \end{matrix}\right\}\left(\dfrac{e^{bt}}{C_{19}}\right)}{\left\{\begin{matrix} MC \\ \hbar \\ OQ \end{matrix}\right\}} + \frac{\left\{\begin{matrix} MC \\ \hbar \\ OQ \end{matrix}\right\}\left\{\begin{matrix} MC \\ \hbar \\ UC \end{matrix}\right\}\zeta}{2}$$

$$TC_{MC} = \left\{\frac{\left[\left\{\sum_{0}^{T_n}\left(\frac{\alpha_0+1}{C_{19}}\right)\right\}\left(\frac{e^{bt}}{C_{19}}\right)\right]}{\left[\sum_{0}^{T_n}\left(\frac{\alpha_2+1}{C_{19}}\right)\right]} + \frac{\left[\left\{\sum_{0}^{T_n}\left(\frac{\alpha_2+1}{C_{19}}\right)\right\}\left\{\sum_{0}^{T_n}\left(\frac{\alpha_1+1}{C_{19}}\right)\right\}\zeta\right]}{2}\right\} \quad (1)$$

3.2 Medicine warehouse

The applicable yearly total Medicine warehouse costs result from the sum of the yearly ordering and transport costs in Medicine warehouse and can be expressed as follows:
$$\left\{\begin{matrix} MW \\ \hbar \\ OC \end{matrix}\right\} = \sum_0^{T_n}\left(\frac{\beta_0+1}{C_{19}}\right)$$

$$\left\{\begin{matrix} MW \\ \hbar \\ UC \end{matrix}\right\} = \sum_0^{T_n}\left(\frac{\beta_1+1}{C_{19}}\right)$$

$$\left\{\begin{matrix} MW \\ \hbar \\ OQ \end{matrix}\right\} = \sum_0^{T_n}\left(\frac{\alpha_2+1}{C_{19}}\right)$$

$$TC_{MW} = \frac{\left\{\begin{matrix} MW \\ \hbar \\ OC \end{matrix}\right\}\left(\frac{e^{bt}}{C_{19}}\right)}{\frac{\phi}{C_{19}}\left\{\begin{matrix} MC \\ \hbar \\ OQ \end{matrix}\right\}} + \frac{\left(\frac{\phi-1}{C_{19}}\right)\left\{\begin{matrix} MC \\ \hbar \\ OQ \end{matrix}\right\}\left\{\begin{matrix} MW \\ \hbar \\ UC \end{matrix}\right\}\left(\frac{\zeta}{C_{19}}\right)}{2}$$

$$TC_{MW} = \left\{\frac{\left[\left\{\sum_0^{T_n}\left(\frac{\beta_0+1}{C_{19}}\right)\right\}\left(\frac{e^{bt}}{C_{19}}\right)\right]}{\left[\frac{\phi}{C_{19}}\left\{\sum_0^{T_n}\left(\frac{\alpha_2+1}{C_{19}}\right)\right\}\right]} + \frac{\left[\left(\frac{\phi-1}{C_{19}}\right)\left\{\sum_0^{T_n}\left(\frac{\alpha_2+1}{C_{19}}\right)\right\}\left\{\sum_0^{T_n}\left(\frac{\beta_1+1}{C_{19}}\right)\right\}\left(\frac{\zeta}{C_{19}}\right)\right]}{2}\right\} \quad (2)$$

3.3 Medicine Manufacturing Sites

The applicable yearly total costs of the Medicine Manufacturing sites result from the sum of the yearly order and the transport costs to the Medicine Manufacturing sites and can be expressed as follows:

$$\left\{\begin{matrix} MMS \\ \hbar \\ OC \end{matrix}\right\} = \sum_0^{T_n}\left(\frac{\gamma_0+1}{C_{19}}\right)$$

$$\left\{\begin{matrix} MMS \\ \hbar \\ UC \end{matrix}\right\} = \sum_0^{T_n}\left(\frac{\gamma_1+1}{C_{19}}\right)$$

$$\left\{\begin{matrix} MMS \\ \hbar \\ OQ \end{matrix}\right\} = \sum_0^{T_n}\left(\frac{\alpha_2+1}{C_{19}}\right)$$

$$TC_{MMS} = \frac{\left\{\begin{matrix} MMS \\ \hbar \\ OC \end{matrix}\right\}\left(\frac{e^{bt}}{C_{19}}\right)}{\frac{\lambda}{C_{19}}\left\{\begin{matrix} MMS \\ \hbar \\ OQ \end{matrix}\right\}} + \frac{\left(\frac{\lambda-1}{C_{19}}\right)\left\{\begin{matrix} MMS \\ \hbar \\ OQ \end{matrix}\right\}\left\{\left\{\begin{matrix} MMS \\ \hbar \\ UC \end{matrix}\right\}\frac{\zeta}{C_{19}}\right\}}{2}$$

$$TC_{MMS} = \frac{\left\{\begin{matrix} MMS \\ \hbar \\ OC \end{matrix}\right\}\left(\dfrac{e^{bt}}{C_{19}}\right)}{\left(\dfrac{\lambda}{C_{19}}\right)\left(\dfrac{\phi}{C_{19}}\right)\left\{\begin{matrix} MMS \\ \hbar \\ OQ \end{matrix}\right\}} + \frac{\dfrac{\phi}{C_{19}}\left(\dfrac{\lambda-1}{C_{19}}\right)\left\{\begin{matrix} MC \\ \hbar \\ OQ \end{matrix}\right\}\left\{\left\{\begin{matrix} MMS \\ \hbar \\ UC \end{matrix}\right\}\dfrac{\zeta}{C_{19}}\right\}}{2}$$

$$TC_{MMS} = \left\{\frac{\left[\left\{\sum_0^{T_n}\left(\dfrac{\gamma_0+1}{C_{19}}\right)\right\}\left(\dfrac{e^{bt}}{C_{19}}\right)\right]}{\left[\left(\dfrac{\lambda}{C_{19}}\right)\left(\dfrac{\phi}{C_{19}}\right)\left\{\sum_0^{T_n}(\alpha_2+1)\right\}\right]} + \frac{\left[\dfrac{\phi}{C_{19}}\left(\dfrac{\lambda-1}{C_{19}}\right)\left\{\sum_0^{T_n}\left(\dfrac{\alpha_2+1}{C_{19}}\right)\right\}\left\{\sum_0^{T_n}\left(\dfrac{\gamma_1+1}{C_{19}}\right)\right\}\dfrac{\zeta}{C_{19}}\right]}{2}\right\} \quad (3)$$

3.4 **Yearly total applicable cost of the Medicine supply chain**

The applicable yearly Medicine supply chain total costs result from the sum of the individual applicable yearly total costs at Medicine Manufacturing sites, Medicine warehouse and medical centers and can be expressed as:

$$TC_{MS} = TC_{MC} + TC_{MW} + TC_{MMS}$$

$$TC_{MS} = \left[\begin{matrix} \left\{\dfrac{\left[\left\{\sum_0^{T_n}\left(\dfrac{\alpha_0+1}{C_{19}}\right)\right\}\left(\dfrac{e^{bt}}{C_{19}}\right)\right]}{\left[\sum_0^{T_n}(\alpha_2+1)\right]} + \dfrac{\left[\left\{\sum_0^{T_n}(\alpha_2+1)\right\}\left\{\sum_0^{T_n}(\alpha_1+1)\right\}\zeta\right]}{2}\right\} \\[4em] + \left\{\dfrac{\left[\left\{\sum_0^{T_n}(\beta_0+1)\right\}\left(\dfrac{e^{bt}}{C_{19}}\right)\right]}{\left[\phi\left\{\sum_0^{T_n}(\alpha_2+1)\right\}\right]} + \dfrac{\left[(\phi-1)\left\{\sum_0^{T_n}(\alpha_2+1)\right\}\left\{\sum_0^{T_n}(\beta_1+1)\right\}\zeta\right]}{2}\right\} \\[4em] + \left\{\dfrac{\left[\left\{\sum_0^{T_n}(\gamma_0+1)\right\}\left(\dfrac{e^{bt}}{C_{19}}\right)\right]}{\left[\lambda\phi\left\{\sum_0^{T_n}(\alpha_2+1)\right\}\right]} + \dfrac{\left[\phi(\lambda-1)\left\{\sum_0^{T_n}(\alpha_2+1)\right\}\left\{\sum_0^{T_n}(\gamma_1+1)\right\}\zeta\right]}{2}\right\} \end{matrix}\right] \quad (4)$$

IV.   TRAVELLING SALESMAN PROBLEM

The Travelling Salesman Problem (TSP) is a widespread computer problem that involves finding a way to Hamilton at minimal cost. The TSP has represented the interests of computer scientists and mathematicians, as the problem is not yet fully resolved, even after about half a decade of research. TSP can be applied to solve many practical problems such as logistics, transportation, semiconductor industry, etc. An effective TSP solution would thus ensure efficient execution of tasks and thus increase

productivity. Due to its importance in many industries, TSP is still studied by researchers from various disciplines. TSP is known to be hard NP. This means that no known algorithm is guaranteed to resolve the optimality of all TSP instances within a reasonable execution time. In order to find exact solutions, various ant colony optimization heuristics and algorithms have been developed to approximate the problems. They allow high quality solutions to be found with reasonable turnaround times. Optimization of ant colonies is generally improvement algorithms; H. You start with one or more possible solutions to the problem in question and suggest ways to improve those solutions. To solve the problem of TSP, researchers have proposed various meta-heuristic approaches such as the optimization of ant colonies to solve TSP.

$$A_{ij} = \begin{cases} 1 & \text{the path goes form city i to city j} \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

$$\min \sum_{i=1}^{N} \sum_{j \neq i, j=1}^{N} D_{ij} A_{ij} \tag{6}$$

$$A_{ij} \in \{0,1\} \qquad \text{i, j-1,...........,N;} \tag{7}$$

$$B_i \in Z \qquad \text{i, =2,...........,n;} \tag{8}$$

$$\sum_{j \neq i, i=1}^{n} A_{ij} \in \{0,1\} \qquad \text{j=1,...........,N;} \tag{9}$$

$$\sum_{j \neq i, j=1}^{n} x_{ij} \in \{0,1\} \qquad \text{i=1,...........,N;} \tag{10}$$

$$B_i - B_j + N A_{ij} \leq N - 1 \qquad 2 \leq i \neq j \leq N \tag{11}$$

$$1 \leq B_i \leq N - 1 \qquad 2 \leq i \leq N \tag{12}$$

V. ANT COLONY OPTIMIZATION

Ant Colony Optimization (ACO) was introduced by Marco Dorigo in 1991 and applied to TSP. The ACO algorithm models the behavior of real ant colonies when determining the shortest path from food sources to nests. Ants can communicate with each other in their immediate environment using chemicals called pheromones. Ants release pheromones to the ground when they leave their nest to feed, then return to the nest. Ants move according to the amount of pheromones. The richer the pheromone trail on a path, the more likely it is that other ants will follow it. So a shorter route has a greater amount of pheromones, ants tend to choose a shorter route. It is thanks to this mechanism that the ants find the shortest way.

5.1 Working of ACO for TSP

Initially, each ant is placed at random on a city. When developing a viable solution, the ants select the next city to visit using a probabilistic decision rule. When an ant k declares in city i and constructs the partial solution, the probability of moving to the next neighbouring city j i is given by

$$[p_0]_{ij}^k(k) = \begin{bmatrix} \dfrac{\left\{[B_0]_{ij}(t_0)\right\}^{\alpha_3}\left\{[C_0]_{ij}\right\}^{\beta_3}}{\displaystyle\sum_{[u_0]\in J_k(t_0)}\left\{[B_0]_{ij}(t_0)\right\}^{\alpha_3}\left\{[C_0]_{ij}\right\}^{\beta_3}} & \text{if } j\in J_k(i) \\[6pt] 0 & \text{otherwise} \end{bmatrix} \quad (12)$$

Where $[B_0]_{ij}$ is the intensity of trails between edge (i,j) and $[C_0]_{ij}$ is the heuristic visibility of the edge

(i, j), and $[C_0]_{ij} = \dfrac{1}{d_{ij}}$ α_3 Is the influencing factor of pheromones, β_3 is the influence of the local node, and $J_k(i)$ is a set of cities that remain to be visited when the ant is in city i. Once each ant has completed their turn, the amount of pheromones on each path will be adjusted with the following equation.

$$[B_0]_{ij}(t_0+1) = (1-\rho_0)[B_0]_{ij}(t_0) + \Delta[B_0]_{ij}(t_0)\,(13)$$

is pheromone evaporation coefficient and$\rho$where

$$\Delta[B_0]_{ij}(t_0) = \sum_{k=1}^{m}\Delta[B_0]_{ij}^k(t_0)\,(14)$$

$$\Delta[B_0]_{ij}^k(t_0) = \begin{bmatrix} \dfrac{Q_0}{[L_0]_k} & \text{if } (i,j)\in \text{tour done by ant k} \\[6pt] 0 & \text{otherwise} \end{bmatrix} \quad (15)$$

 $(1-\rho)$ is the decay parameter of pheromones $(0<\rho<1)$ where it represents the evaporation of the track when the ant chooses a city and decides to move. Lk is the length of the turn for each formed per ant k and m is the number of ants. Q is the pheromone deposition factor.

VI.   NUMERICAL ILLUSTRATION

To understand the quantified effects of the proposed model, let us take a numerical representation. This gives us a clear idea of how ant colony optimization relates to the travelling salesman problem with the help of practical examples. The following numerical data is taken into account for the co-ordinated supply chain problem considered to illustrate the model presented.

$$\begin{Bmatrix} MC \\ \hbar \\ OQ \end{Bmatrix} = \text{EUR150/order} \quad \begin{Bmatrix} MC \\ \hbar \\ UC \end{Bmatrix} = \text{EUR140/unit} \quad \begin{Bmatrix} MW \\ \hbar \\ OQ \end{Bmatrix} = \text{EUR125/order} \quad \begin{Bmatrix} MW \\ \hbar \\ UC \end{Bmatrix} = \text{EUR190/unit}$$

$$\begin{Bmatrix} MMS \\ \hbar \\ OQ \end{Bmatrix} = \text{EUR150/setup} \quad \begin{Bmatrix} MMS \\ \hbar \\ UC \end{Bmatrix} = \text{EUR150/unit} \quad \zeta = \text{EUR0.2/Re/Months} \quad D = 7{,}000 \text{ units}$$

By applying the ant colony optimization and the travelling salesman problem to the data given above, equation (4) is solved to obtain the optimal values of the decision variable and the objective function and the results are presented in Table I.

Table I: Best Values of result Variables and purpose Function With and without management

Item Description	Travelling salesman problem	Ant Colony Optimization
$\left\{\begin{array}{c} MC \\ \hbar \\ OQ \end{array}\right\}$	387 units	369 units
$\left\{\begin{array}{c} MW \\ \hbar \\ OQ \end{array}\right\}$	1161 units	738 units
$\left\{\begin{array}{c} MMS \\ \hbar \\ OQ \end{array}\right\}$	1161 units	738 units
Positive integer (Inventory ratio ϕ)	15	12
Positive integer (Inventory ratio λ)	10	10
TC_{MMS}	EUR 7356/-	EUR 7,198.5/-
TC_{MW}	EUR 9872.9/-	EUR 8,614.1/-
TC_{MC}	EUR 5813.9/-	EUR 7,032.3/-
TC_{MS}	EUR 23,042.9/-	EUR 22,840.6/-

From the table above, we show the comparison of the applicable total costs obtained from the two algorithms considered. Here, the resulting inventory ratio is assigned to a positive integer value shown in the table. The values of the decision variables and the objective function are optimized with both methods and then mapped side by side. We see that the total supply chain cost resulting from the street vendor problem is lower than that obtained by the ant colony optimization algorithm. 1 shows the continuous decrease of the applicable total costs up to a certain value of generations and shows a saturated behavior with an increasing number of generations.

VII. CONCLUSIONS

This article provides a comparative study as part of a line of research examining optimal inventory decisions regarding the impact of the Covid-19 pandemic on the inventory management of the Medicine supply chain at three levels in medical centers. The comparison is based on the algorithm used to solve the three-level problem illustrated by a numerical example. The model compares the applicable optimized total costs at Medicine Manufacturing sites, Medicine warehouse and medical centers. It is observed that the replenishment of the medical center is higher in the ant colony optimization method, with a similar number of shipments, as shown by positive integer values. In addition, it is worth noting that the traveling salesman problem, compared to the optimization of the ant colony, provides inferior for each formance for the applicable total cost of the whole chain. Therefore, it can be concluded from the comparative study that the traveling salesman problem produces better optimal values for decision variables and objective functions. The scope of the project is cited in industrial applications such as storage optimization in industry.

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