

# **Inventory Management of Non- Instantaneous Deteriorating Items Using Particle Swarm Optimization Technique**

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## **Abstract**

The paper seeks to address the inventory management problems of perishable food items being faced in a firm. We have provided a solution approach to the managers to help them in planning based on customer behavior and demand. The inventory management of perishable or Non- Instantaneous deteriorating items is the biggest issue in the present global market conditions. Due to the organoleptic properties of perishable inventory, it is difficult to maintain the standard. Variation in demand patterns is an important parameter to be considered from the management perspective. In this study, we used a Particle Swarm Optimization technique to optimize the inventory problem. The proposed method predicts the probability of demand and demand pattern at a particular period through particle swarm optimization and analyzed understock and overstock strategy of the fast food delivery firms.

## **Keywords**

Food items, Non- Instantaneous deteriorating item, Particle swarm optimization, Replenishment cycle, Inventory management.

## **1. Introduction:**

Inventory management of Non-instantaneous deteriorating items (NIDIs) depends on internal, external activities, and available resources of the firm (Tiwari et al. 2017). Deterioration is the most common phenomenon in the fast-food industry. Kamble et al. 2019b discussed the modeling of adoption barriers in the food retail supply chain. Sethi and Shruti (2006) stated that about 20% of food items never reach to the customers leading to the deterioration of the inventory resulting in low availability of items and reduced profit.

In the present era, the most widely research problem is the upholding of NIDIs. Deterioration is defined as the spoilage, damage, dryness and vaporization, that reduces the useful life of the product (Li et al., 2019, Tashakkor et al., 2018, Udayakumar et al., 2018, Ahmad et al., 2018). Generally, the inventory managers not accounting for the perishability of items (Chang et al. 2008, Pérez et al., 2019, Kamble et al., 2019a). The purpose of our research is to target optimal production scheduling and inventory management under continuous or stochastic demand situations. The conceptualization, key dominating aspects, and factors which affects the availability of NIDI's is presented in figure 1 and figure 2.

The main aim of this paper is to provide an optimal solution for inventory (understock and overstock) by using particle swarm optimization (PSO) for variable consumer demand. We have chosen PSO because its suitable for highly nonlinear optimization problem based on Metaheuristic local search algorithm (Tiwari et al., 2017). In this paper, we have used discrete function simulation to explain the operating conditions of different parameters of the system that included replenishment rate, order quantity and service rate. Further, we have investigated the optimal solution for the replenishment rate and ordered quantity with use of a real-life example.

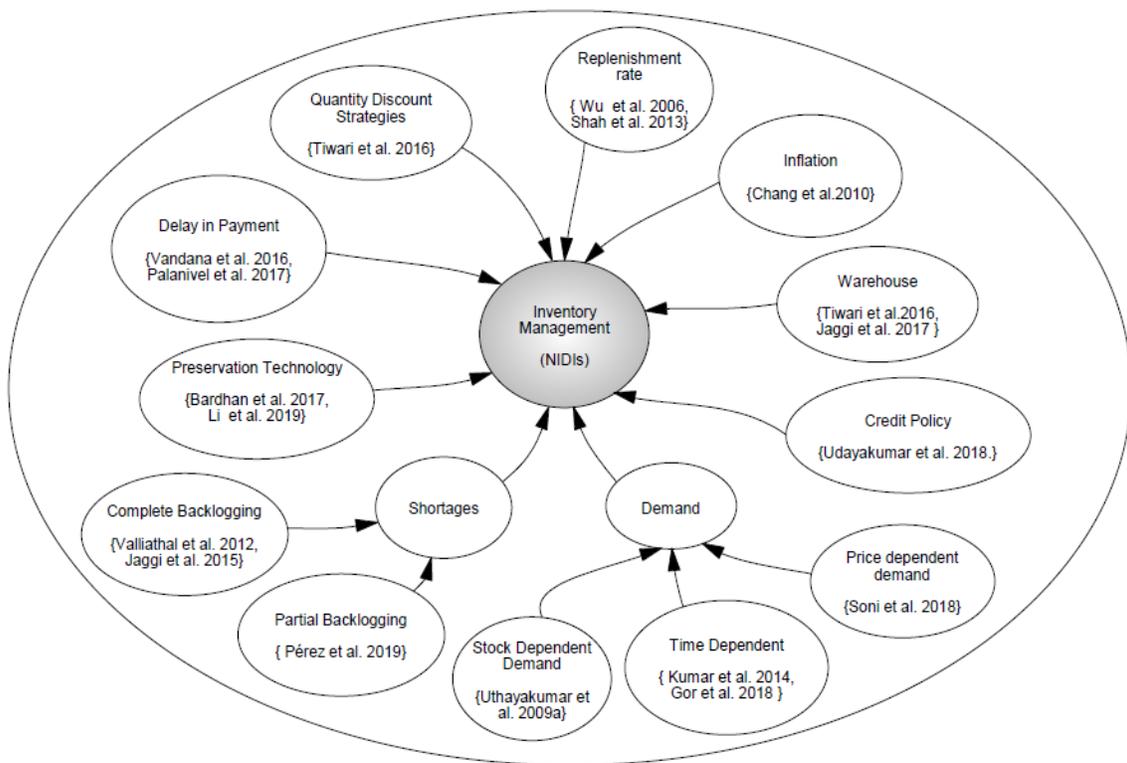


Figure 1. Conceptualization and Factor identification of NIDIs

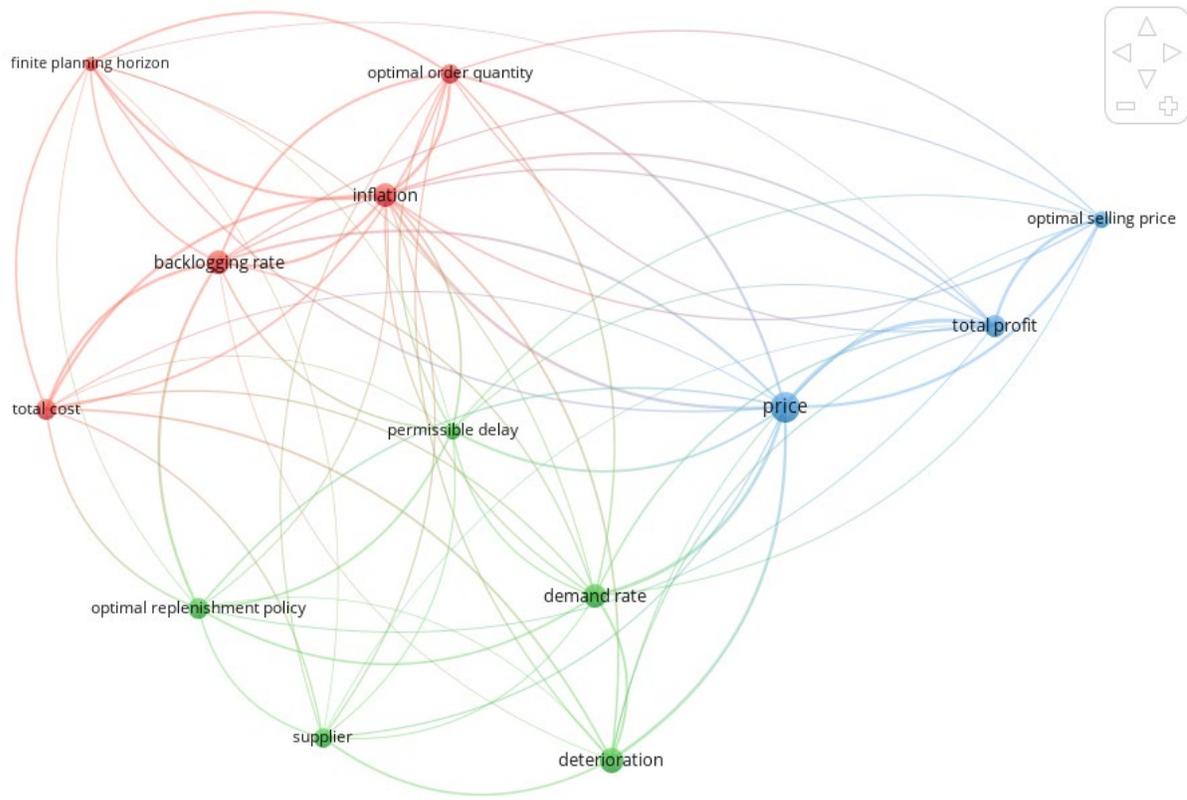


Figure 2. The dominance of key aspects in NIDIs modeling (Scopus database)

The optimal quantity leads to minimizing two significant associated costs i.e., the holding and ordering costs (Shah et al. 2013, Mishra et al., 2018). In the same context, Ouyang et al., (2008) formulated an optimal solution to provide a robust mathematical algorithm calculate optimal order quantity and replenishment time. Chang et al. (2010) suggests existence of relationship between optimal order quantity and total relevant cost. Geetha et al. (2010) proposed model for the retailer to specify the optimal replenishment strategy for NIDI's under permissible delay in payments and promotion offer by suppliers. They formulated an algorithm to solve an inventory policy for EOQ (Economic order quantity) and optimal replenishment cycle time. Sugapriya et al., (2008) helps to decrease the overall cost for non instantaneous deterioration. Yang et al., (2009) have used price discount, time-dependent holding cost in their algorithm, contributing to the previous literature in several ways. First of all, it intimated the concept of NIDI's under the consideration of demand rate, price sensitive demand rate and partial backlogging, hitherto not mentioned in the previous studies. Secondly, it provides an algorithm for optimal selling price and length of the replenishment cycle. Maihami et al. (2012) developed an inventory system with price-sensitive demand and non-instantaneous replenishment. The aim of their study was to determine the length of the replenishment cycle and optimal selling price such that the overall profit per unit time is maximum for the firm (Lashgari et al, 2018, Pal et al., 2018, Palanivel et al., 2018, Pundir et al., 2019a,b).

The remainder of this paper is organized as follows: problem description, methodology, experimental approach and conclusion remark.

## 2. Problem Description:

We have studied the understocking and overstocking problem of fast-food supplying and delivering firm, which delivered the fast food item ‘A’. The firm usually opens at 07:00 AM and deliver items according to demand. The main constraints are shelf life of the product which is supposed to expire six to ten hours after the production. All the expired product is subsequently abandoned. The manager of the firm can neither make overstock which leads to spoilage, and nor maintain understock due to loss of profit. The situation, this represents the dynamic complexity of the system.

Figure 3 and 4 represent the demand rate. In the present study work we are predicting the next day demand rate based on hourly basis demand. We have excluded the constraints like weather condition, rate of inflation, advertisement effect, cash discount, credit term, credit standard, lead time, customer returns were excluded from the study.

### 2.1 Discrete Event Simulation Model:

The following notation is used to develop the Discrete Event Simulation (DES) model-

Table. 1 Notations

Attributes	Notations
The number of items expiring	D
The weight of D in the objective function	Wd
The number of customers renegeing	R
The wight of R in the objective function	Wr
The i th replenishment time	$t_i$ where $t_i < t_{i+1}$
The upper and lower bound of replenishment time $t_i$	$t_i^u$ & $t_i^l$
The lower bound and the upper bound for Calculating $t_i^u$ & $t_i^l$	$r_l$ & $r_u$
The shelf life of an item, in minutes	L
The lower bound and the upper bound of $Q_i$ respectively, in units.	$q_i^u$ & $q_i^l$
The replenishment quantity at $t_i$ , $q_i \in Q$ .	$q_i$

We have encoded two n-tuples to solve the problem

$$s = t_0, t_1, t_2, t_3, t_4, t_5 \dots \dots t_n$$

represent the replenishment times

$$s = q_0, q_1, q_2, q_3, q_4, q_5 \dots \dots q_n$$

represent the replenishment quantities

The problem formulation and constraints are as follows:

Objective function:

$$\min w_d d + w_r r \dots \text{Eq. 1}$$

Subject to:

$$t_i^l \leq t_i \leq t_i^u \quad i \in I \dots \text{Eq. 2}$$

$$q_i^l \leq q_i \leq q_i^u \quad i \in I \dots \text{Eq. 3}$$

### 3. Methodology:

The framework of the solution method is shown in figure 3.

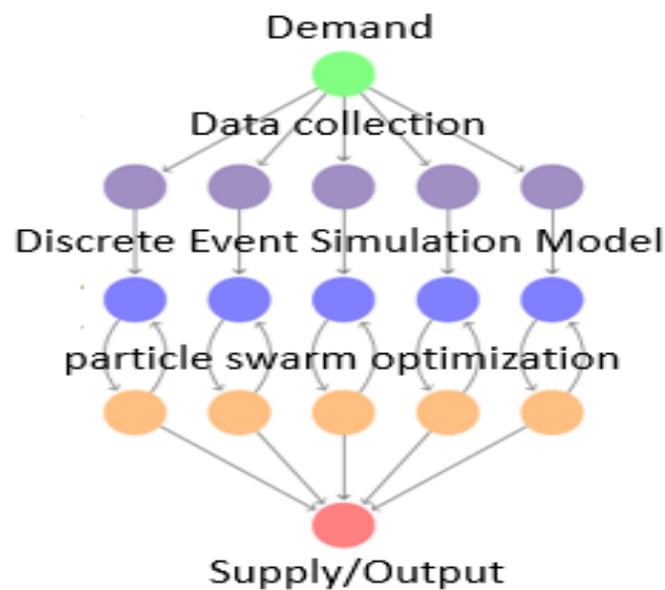


Figure 3. Solution Methodology framework

#### 3.1 Data Collection:

Step 1: First, we have examined the historical pattern of customer arrival rate in time interval.

Step 2: Erlang density function as shown in figure 4, was used to determine the probability and actual service rate of firm.

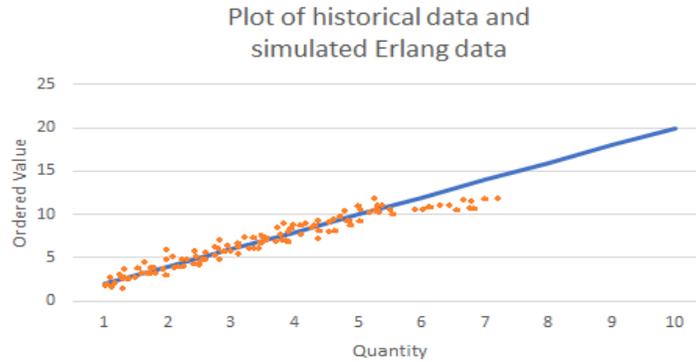


Figure 4. Plot of historical data and simulated Erlang data

Step 3: In next step, we have generated the number of units that would be sold in each transaction.

### 3.2 Implementation of Particle Swarm Optimization (PSO)

We have used PSO because of the following reasons (Ou et al. 2006, Tiwari et al. 2017).

1. PSO tends to have mature convergence according to its search strategy.
2. PSO provide n dimensions search space.

## 4. Experimental Approach

A numerical example is demonstrated to illustrate the proposed solution methodology. MATLAB was used for running the solution and coded algorithms on 1.80 GHz Intel core i5 with 8 GB of memory RAM computer.

Let us assume

Life of the perishable product = 8 hours (from historical data)

According to Shaikh et al. (2017) PSO algorithm required 4 parameters which are Number of particles in the population (n), Inertia weight in a particle's movement (w), Personal Best (PBEST) and Group Best (GBEST). We have considered 500 iterations.

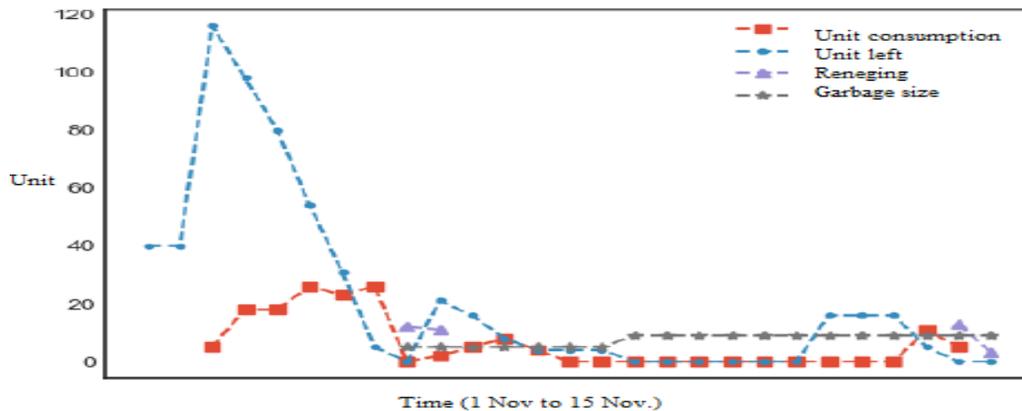


Figure 5: Non-optimal solution

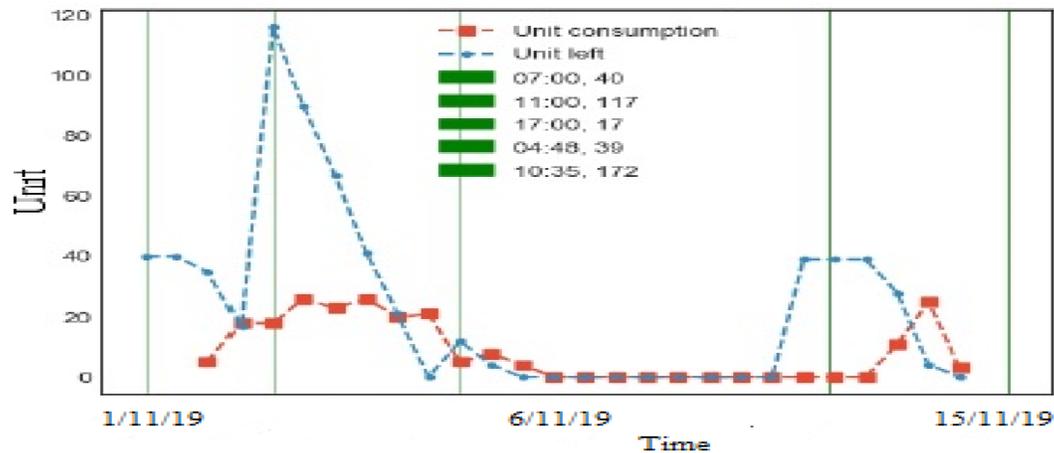


Figure 6. Optimal solution for instance

#### 4.1 Results:

We have represented time duration on X-Axis & units on Z-axis in figure 5 and 6. The results are following-

1. Maximum number of customers (n=117) arrived during the period 9:00am to 11:00 am, Therefore, At this duration the firm need to maintain optimal quantity for maximum profit)
2. There is small incremental change in demand in odd day of the month.

#### 5. Conclusions remarks

In this paper we have used perishable product as an inventory. By the formulation of mathematical model and simulation of optimal problem, we can predict the demand in each planning origin. We have generated the consumption pattern for 15 days period and analyzed that the odd day of the month has higher number of customer arrival as well as during the morning session 9 am to 11 am, there is sudden change in demand pattern. The main propose of this paper is to analyze the demand and behavior of customer, so the firm manager can avoid the understock and overstock situation.

In future we can focus on stochastic demand with multi objective optimization problem with varying lead time.

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