LAPORAN AKHIR PENELITIAN

Heuristic Algorithm based on Consecutive Method for Inventory Policy with Partial Backlog Case and Deterministic Demand

oleh:

Ririn Diar Astanti, S.T., M.MT., D.Eng.

PROGRAM STUDI TEKNIK INDUSTRI

FAKULTAS TEKNOLOGI INDUSTRI

UNIVERSITAS ATMA JAYA YOGYAKARTA

2012

LEMBAR PENGESAHAN

a. Judul Penelitian	:	**Heuristic Algorithm based on Consecutive Method for Inventory Policy with Partial Backlog Case and Deterministic Demand**
b. Macam Penelitian	:	Laboratorium
Peneliti		
a. Nama	:	Ririn Diar Astanti, S.T., M.MT., D.Eng.
b. Jenis Kelamin	:	Perempuan
c. Usia saat pengajuan proposal	:	33 tahun 6 bulan
d. Jabatan Akademik/Gol	:	Asisten Ahli / IIIb
e. Fakultas / Program Studi	:	Teknologi Industri / Teknik Industri
Jumlah Peneliti	:	1 (satu) orang
Lokasi Penelitian	:	Yogyakarta
Jangka Waktu Penelitian	:	4 (empat) bulan
Biaya yang diajukan	:	Rp 3.000.000,- (Tiga juta rupiah)

Yogyakarta, 16 Maret 2012

Ketua Peneliti,

Ririn Diar Astanti, S.T., M.MT., D.Eng.

Mengetahui,

Kepala Lab. Pemodelan dan Optimasi

V. Ariyono,S.T., M.T.

Dekan FTI UAJY,

Y.B.Kristyanto,M.Eng,Ph.D

Ketua LPPM UAJY,

Dr.Ir.Y.DjarotPurbadi, M.T

Keterangan:

Hasil penelitian ini telah diseminarkan pada International Conference on Industrial Engineering and Service Science (IESS) 2011, 20-21 September 2011, di Surakarta, Indonesia dan paper tersebut terpilih sebagai salah satu paper yang layak untuk dipublikasikan ke jurnal internasional. Adapun bukti paper dan bukti bahwa paper tersebut terpilih sebagai salah satu paper yang terpilih untuk dipublikasikan di jurnal internasional terlampir.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Originally, the consecutive method was proposed by (Wang, 2002a) to determine inventory policy for the non shortage case. Later on Astanti and Luong (2009) extended the work of Wang by developing new algorithm based on consecutive method for shortage case but limited on completely backlog situation. It is noted that the shortage case is the situation when customer arrive but the goods are not there. When all customers are willing to wait until the next replenishment, it is called completely backlog situation. However, in the real situation it often happens that some customers are willing to wait, but the other prefers to find another supply sources, or it is called partial backlog case. The work of this research, therefore are going to develop the algorithm for determining inventory policy with partial backlog case.

Keywords: Inventory policy, heuristic, consecutive method, partial backlog

CHAPTER 1
INTRODUCTION

1.1. Introduction

Inventory policy deals with "*management of stock level of goods*" (Heyman and Sobel, 1990) and comprises of decisions about when and how much the order/production should be placed. Those decisions are crucial, since a company have to manage its inventory properly in order to meet customer's demands with minimum cost.

Before developing an inventory policy, demand should firstly be estimated. Demand of a particular products itself has either probabilistic or deterministic characteristic. Many researches on inventory policy have been done dealing with probabilistic demand such as Silver (1978), Askin (1981), Wemmerlöv and Whybark (1984), Bookbinder and H'Ng (1986), Vargas and Metters (1996), Bollapragada and Morton (1999), Tarim and Kingsman (2004), Tarim and Kingsman (2006), and Pujawan and Silver (2008), among others. However, the focus of this research is on deterministic demand. It is noted that if the result of the developed algorithm is promising for the case of deterministic demand, then the developed algorithm will be extended to the case of probabilistic demand.

Based on the research that was done by Astanti and Luong (2009) it shows that the results of heuristic algorithm based consecutive method are comparable to the results of other methods, especially for the case of deterministic demand and completely backlog case. More over that method is easy in concept and computationally simple. It is noted that the completely backlog case is the situation when customer arrive but the goods are not there, but all customers are willing to wait until the next replenishment. However, in the real situation it often happens that some customers are willing to wait, but the other prefers to find another supply sources, or it is called partial backlog case.

Even though many researches have been done in the area of inventory especially in the case of deterministic and backlog case, the research in this area is still interesting as the problem of inventory always appears in practical situation. Therefore, finding the algorithm that are easy for the practitioners to understand and computationally simple is challenging.

1.2. Problem Statement

As it is mentioned in the previous section that the result of heuristic method based on consecutive method for completely backlog case are comparable to the results of other methods. This has inspired the research in this proposal which is focusing on developing the heuristic algorithm to help determine optimal operational parameters of inventory policy for partial backlog case. As the problem of inventory appears in practical situation then the development of algorithm to solve inventory problem that is easy for the practitioner to understand and computationally simple will be developed in this research.

1.3. Objective

The primary objectives of this research is to develop heuristic algorithm based on consecutive method to help find optimal operational parameters, i.e., replenishment times and shortage points, for the case of deterministic demand and partial backlog case that are easy in concept, computationally simple but still providing good results.

CHAPTER II
LITERATURE REVIEW

The literature review on inventory policies in this section focuses only on deterministic demand shortage case, especially partial backlog case. In reality, the shortage period might occur in each replenishment cycle, e.g., when customer arrives, no stocks of goods are available. From the standpoint of supplier, shortage sometimes is economically preferable, e.g., when holding cost is significant high as compared with shortage cost. The shortage case can be divided into two which are completely backlog and partial backlog cases.

Inventory models with infinite planning horizon of partial backlog case with fixed fraction of backlog had been proposed in (Montgomery,1973). They developed models and solution technique for not only constant demand rate, but also stochastic demand rate, in which covers continuous and periodic review models. The work had been extended by considering customer impatience into the fraction of backlogged demand, in which the backlog fraction is modeled as linear function (San Jose, 2005) and general non increasing function (San Jose, 2005). Instead of infinite planning horizon, a finite planning horizon model for this situation (Zhou,2004) developed the heuristic method for SFI policy, not only for linear increasing but also for nonlinear increasing demand.

The summary of the past related researches and their characteristics is presented in Table 2.1 below.

Tabel 2.1. Literature Review on Inventory Policy with Partial Backlog Case

Author	Horizon		Demand's characteristic		Demand Pattern					Deterioration		Shortage		Type of shortage		Method		Note
						Increasing		Decreasing										
	F	I	D	S	C	L	NL	L	NL	Yes	No	Yes	No	CO	PR	H	E	
Montgomery (1973)	√		√		√						√	√			√	√		Fraction of backlogged demand is fixed.
Zhou, et al. (2004)	√		√			√	√				√	√			√	√		Shortage is not allowed to happen at the end of planning horizon. Partial backlog rate as waiting-time-dependent.
Jose (2005)	√		√		√						√	√			√	√		Backlogging rate is a continuous and non increasing two piece function.
Jose (2006)	√		√		√						√	√			√	√		Fraction of backlogged demand is negative exponential function of the waiting time.

Note:

F: Finitte	D: Deterministic	C:Constant	NL: Non Linear	PR: Partial	E: Exact
I:Infinite	S: Stochastic	L:Linear	Co: Completely	H: Heuristic	

CHAPTER III
MATHEMATICAL MODEL

Basic mathematical model in this research is developed based on the following assumptions:

a) The mixture of backorders and lost sales during the stock out period is known and constant. p is the probability that an order will be backlog when shortage occurs, therefore the fraction of lost sales is $(1-p)$.

b) The replenishment is made at time t_i $(i=1,2,...,n)$

c) The quantity received at t_i is used partly to meet accumulated backordered in the cycle from time s_i to t_i $(s_i < t_i)$

d) The inventory at t_i gradually reduces to zero at s_{i+1} $(s_{i+1} > t_i)$, in which a new cycle starts.

e) Shortages are permitted in the beginning of the period ($s_1 = 0$) but no shortages are permitted at the last cycle ($s_{n+1} = H$)

The behavior of inventory level function of the inventory problem that is considered in this paper is presented in Figure 3.1.

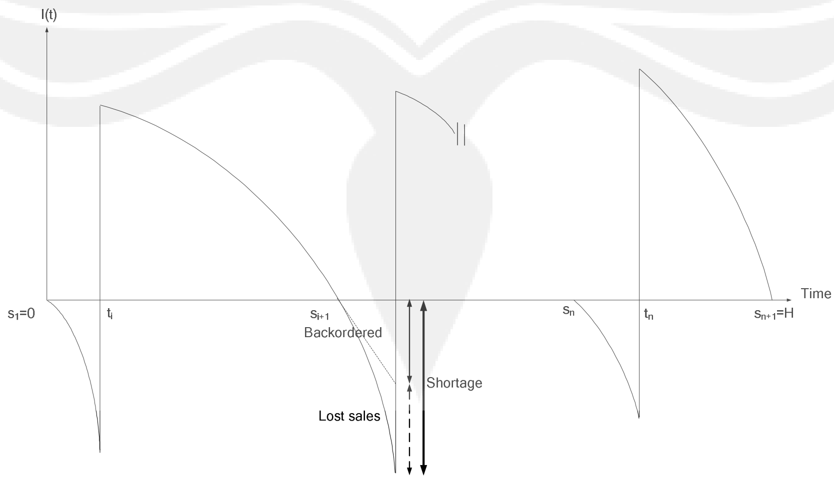

Figure 3.1. Inventory level over the whole planning horizon

The notations that are used in this research are as follows:

H length of the planning horizon under consideration

$f(t)$ instantaneous demand rate at time t

c_{1f} fixed ordering cost per order

c_{1v} variable purchasing cost per order

c_2 holding cost per unit per unit time

c_{3s} the backlogging cost per unit per unit time due to shortages

c_{3l} the unit cost of lost sales

n number of replenishment over $[0, H]$

t_i the ith replenishment time $(i = 1,2,...,n)$

s_i the shortage point at cycle i, which is the time at which the inventory level reaches zero in the ith cycle $[s_i, s_{i+1}]$; except that $(s_{i+1} = H)$

$I(t)$: inventory level at time t, that is evaluated after replenishment arrives at time $t = t_i$

in the ith cycle $[s_i, s_{i+1}]$

Using the assumptions above, the expression for the total cost which includes ordering cost, variable purchasing cost, holding cost, backlog cost, and cost of lost sales, total cost of the inventory system during the planning horizon H when n order are placed is as follows:

$$C\left(n, \{s_i\}, \{t_i\}\right) = \sum_{i=1}^{n} P_i + c_2 I_i + c_{3s} S_i + c_{3l} L_i \qquad (3.1)$$

in which

I_i is the inventory level during ith cycle

$$I_i = \int_{t_i}^{s_{i+1}} \int_{t}^{s_{i+1}} f(\tau) d\tau dt = \int_{t_i}^{s_{i+1}} (t - t_i) f(t) dt \qquad (3.2)$$

P_i is the purchase cost during the ith replenishment cycle, and as:

$$P_i = c_{1f} + c_{1v} \left[\int_{si}^{ti} pf(t) dt + \int_{t_i}^{s_{i+1}} f(t) dt \right] \qquad (3.3)$$

S_i is the amount of backordered during ith cycle, as:

$$S_i = \int_{s_i}^{t_i} S(t)dt \tag{3.4}$$

$$S_{i=} \int_{s_i}^{t_i}\int_{s_i}^{t} pf(\tau)d\tau dt = p\int_{s_i}^{t_i}(t_i - t) f(t)dt$$

L_i is the number of lost sales during ith cycle, as:

$$L_i = \int_{s_i}^{t_i}(1-p) f(t)dt \tag{3.5}$$

From (2), (3), (4), and (5) the expression of the total cost can be defined as:

$$\begin{aligned} C\left(n,\{s_i\},\{t_i\}\right) = \sum_{i=1}^{n} c_{1f} + c_{1v}\left[\int_{si}^{ti} pf(t)dt + \int_{t_i}^{s_{i+1}} f(t)dt\right] + c_2\int_{t_i}^{s_{i+1}}(t-t_i) f(t)dt \\ + c_{3l}\int_{s_i}^{t_i}(1-p) f(t)dt + c_{3s}\, p\int_{s_i}^{t_i}(t_i - t) f(t)dt \end{aligned} \tag{3.6}$$

CHAPTER 1V

DEVELOPMENT OFALGORITHM BASED ON CONSECUTIVE METHOD

From (3.6), it can be seen that the total inventory cost function can be determined if we know the value of replenishment time t_i 's and shortage points s_i 's. In this paper, the value of shortage point s_i 's is determined by using consecutive method proposed by Wang (2002a), who originally developed it to find replenishment time t_i 's for non-shortage case. Then, the proposed heuristic technique is applied to determine replenishment time t_i 's. It is noted that the main idea of both Wang's consecutive method and the proposed heuristic technique is to check if there are any possibilities to reduce the total cost. Detail procedures to find replenishment time t_i 's are explained in Section 4.1.

4.1. Procedure to find $\{t_i\}$

Replenishment times t_i 's in each cycle i can be determined by solving a maximization problem, with the objective function is to maximize the reduction cost. Reduction cost here is defined as the difference between the cost of holding the inventory with cost of backorder and lost sales. The reduction cost is presented graphically in Figure 4.1 and can be written as follows:

$$\text{Maximize } RC^{(i)} = c_2\left(\int_{s_i}^{t_i}\int_{t}^{s_{i+1}} f(t)dtdt\right) + \left(c_{1v} - c_{3l}\right)\left(\int_{s_i}^{t_i}(1-p)f(t)dt\right) - c_{3s}\left(\int_{s_i}^{t_i}\int_{s_i}^{t} pf(t)dtdt\right) \quad (4.1)$$

Subject to

$$s_i \le t_i \le s_{i+1}$$

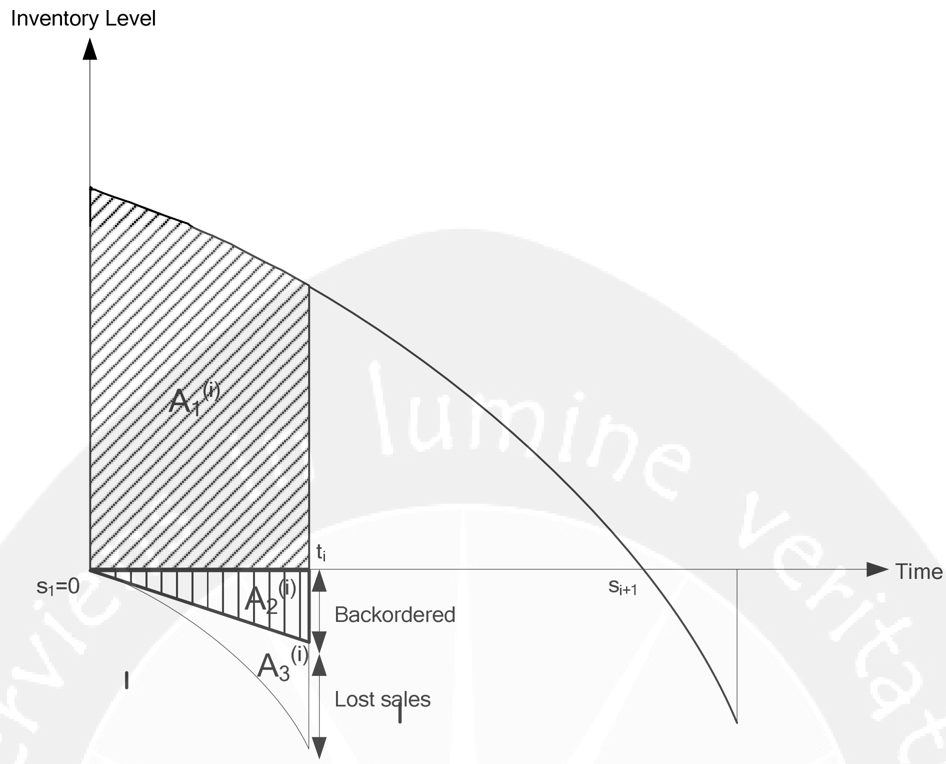

Figure 4.1. Reduction cost

If the maximum reduction cost give the positive value it means that a replenishment is allowed to be occurred during the cycle i, otherwise a replenishment is not allowed to be occurred, since the negative value of reduction cost means that a replenishment will increase the total cost.

If t_i^* is the optimal time for replenishment time during the interval $[s_i, s_{i+1}]$, then t_i^* satisfies the Equation 4.2 :

$$\frac{dRC^{(i)}}{dt_i} = [c_2F(s_{i+1}) - c_2F(t_i) + c_{1v}(1-p)f(t_i)] - [c_{3l}(1-p)f(t_i) - c_{3s}pF(s_i) + c_{3s}pF(t_i)] = 0 \qquad (4.2)$$

As the demand rate $f(t)$ is assumed to be increasing and $c_{3l} > c_{1v}$, the second-order derivative is :

$$\left.\frac{d^2RC^{(i)}}{dt_i^2}\right|_{t_i=t_i^*} = -c_2 f(t_i) + (1-p)f^{'}(t_i)(c_{1v} - c_{3l}) - c_{3s}pf(t_i) < 0 \,,$$

which implies that we can reach the maximum point at $t_i = t_i^*$.

4. 2. Numerical Example

To illustrate the result, we apply the proposed methods to solve the numerical example. The example is similar with the example on (Dye, 2006), but in this paper no deterioration rate is applied, and the fraction of backorder is fixed ($fp = 0.3$) and also in order to meet the assumption that $c_{3l} > c_{1v}$, therefore the value of c_{3l} and c_{1v} are changed.

Example 1.

Let $f(t) = 50 + 3t$, $H = 4$, $c_{1f} = 250$, $c_{1v} = 200$, $c_2 = 40$, $c_{3s} = 80$, $c_{3l} = 220$.

This example is then solved by the proposed method using Matlab 7.1, and the result is presented below in Table 4.1 with total cost of 48913.98 and the detail result is presented in Table 4.2. In addition the code of the program is provided in Appendix 1.

Table 4.1. Replenishment Schedule for Example 1

cycle *i*	t_i	s_i
1	0.1119	0
2	0.6307	0.5238
3	1.1421	1.0398
4	1.6466	1.5487
5	2.145	2.0507
6	2.6373	2.5471
7	3.1236	3.0371
8	3.6043	3.5214
9		4

Table 4.2. Result of Numerical Example

i	*T*	*i*	*s*	*F(t)*	*F(s)*	*FF(t)*	*FF(s)*	*Holding*	*Shortage Backordered*	*Lost sales*	*Quantity order*	Holding cost	*Shortage cost*	*Lostsales*	*Variable Ordering Cost*
1.00	0.1119	1.00	0.0000	5.6142	0.0000	0.3138	0.0000	4.3392	0.0941	3.9300	22.6703	173.5675	7.5310	864.5917	4534.0612
2.00	0.6307	2.00	0.5238	32.1312	26.6003	10.0697	6.9304	4.4112	0.0886	3.8717	23.1401	176.4462	7.0889	851.7691	4628.0154
3.00	1.1421	3.00	1.0398	59.0642	53.6120	33.3575	27.5920	4.4833	0.0836	3.8165	23.6061	179.3310	6.6894	839.6277	4721.2295
4.00	1.6466	4.00	1.5487	86.3985	81.0347	70.0170	61.8219	4.5522	0.0787	3.7547	24.0565	182.0884	6.2954	826.0336	4811.2933
5.00	2.1450	5.00	2.0507	114.1500	108.8458	119.9571	109.4516	4.6272	0.0749	3.7129	24.5260	185.0888	5.9923	816.8449	4905.1953
6.00	2.6373	6.00	2.5471	142.2968	137.0847	183.0524	170.4510	4.6936	0.0705	3.6484	24.9600	187.7445	5.6378	802.6571	4992.0031
7.00	3.1236	7.00	3.0371	170.8167	165.6932	259.1643	244.6127	4.7601	0.0664	3.5865	25.3910	190.4025	5.3135	789.0246	5078.2033
8.00	3.6043	8.00	3.5214	199.6987	194.6707	348.1771	331.8405	4.8241	0.0624	3.5196	25.8097	192.9624	4.9954	774.3147	5161.9414
9.00		9.00	4.0000	0.0000	224.0000	0.0000	432.0000	0.0000		**29.8403**	**194.1597**	1467.6312	49.5437	6564.8633	38831.9425
10.00		10.00									**224.0000**				
11.00		11.00													
12.00															
														TC	**48913.98**

Example 2.

The second example is applied for the case when the demand rate is constant.

In this case $f(t) = 3t$ $H = 4$, $c_{1f} = 250$, $c_{1v} = 200$, $c_2 = 40$, $c_{3s} = 80$, $c_{3l} = 220$.

This example is then solved by the proposed method using Matlab 7.1, and the result is presented below in Table 2 with total cost of **6126.14.**

Table 2. Replenishment Schedule for Example 2

cycle *i*	t_i	s_i
1	**0.8004**	**0**
2	**1.7439**	**1.3333**
3	**2.6564**	**2.3094**
4	**3.4955**	**3.2041**
5		**4**

CHAPTER V
DISCUSSION AND FURTHER WORK

Based on the numerical examples provided in the previous section, it can be seen that the proposed algorithm works for the case of linear increasing demand. Further work will be conducted to explore the application of the proposed method to more varying demand pattern. In addition, the proposed method will be compared to other heuristic method i.e. Nelder Mead technique proposed by Chen (2007).

REFERENCES

Askin, R. G. (1981). A procedure for production lot sizing with probabilistic dynamic demand. *AIIE Transaction,* 13(2), 132–136

Bookbinder, J. H., H'Ng, B-T. (1986). Rolling horizon production planning for probabilistic time-varying demands. *International Journal of Production Research,* 24(6), 1439–1458

Bollapragada, S., and Morton, T.E. (1999). A simple heuristic for computing non stationary (s, S) policies. *Operations Research,* 47(4), 576–584

Chang, H-J, and Dye, C-Y (1999). And EOQ model for deteriorating items with time varying demand and partial backlogging. *Journal of the Operational Research Society*,50(1999), 1176–1182

Chen, C.K., Hung, T.W., & Weng, T.C. (2007) Optimal replenishment policies with allowable shortages for a product life cycle. *Computers and Mathematics with Applications, 53*, 1582-1594.

Dye, C. Y., Chang, H. J., Teng, J. T. (2006) A deteriorating inventory model with time- varying demand and shortage-dependent partial backlogging. *European Journal of Operational Research*, 172 (2), 417–429.

Heyman, D. P., and Sobel, M. J. (1990). *Handbook in Operation Research and Management Science (Volume 2).* Netherlands: Elsevier Science Publisher B.V.

Montgomery, D. C., Bazaraa, M. S., & Keswani, A. K. (1973). Inventory model with a mixture of backorders and lost sales. *Naval Research Logistics*, 20(2), 255–263

Pujawan, I.N., and Silver, E. A. (2008). Augmenting the lot sizing order quantity when demand is probabilistic. *European Journal of Operational Research,*188(2), 705–722

Silver, E. A. (1978). Inventory control under a probabilistic time-varying, demand pattern. *AIIE Transaction,* 10(4), 371–379

San Jose, L. A., Sicilia, J., and Garcia-Laguna, J. (2005). An inventory system with partial backlogging modeled according to a linear function. *Asia-Pacific Journal of Operational Research*, 22(2), 189–209

San Jose, L. A., Sicilia, J., and Garcia-Laguna, J. (2006). Analysis of an inventory system with exponential partial backordering. *International Journal of Production Economics*, 100(1), 76–86

Tarim, S.A., and Kingsman, B. G. (2004). The stochastic dynamic production/inventory lot-sizing problem with service-level constraint. *International Journal of Production Economics* ,88(1), 105–119

Tarim, S.A., and Kingsman, B. G. (2006). Modelling and computing $\left(R^n, S^n\right)$ policies for inventory systems with non-stationary stochastic demand. *European Journal of Operational Research*, 174(1), 581–599

Vargas, V. A., and Metters, R. (1996). Adapting lot-sizing technique to stochastic demand through production scheduling policy. *IIE Transaction*, 28(2), 141–148

Wang, S. P. (2002a). On inventory replenishment with non-linear increasing demand. *Computers and Operations Research*, 29(13), 1819–1825

Wemmerlöv, U., and Whybark, D.C. (1984). Lot-sizing under uncertainty in a rolling schedule environment. *International Journal of Production Research*, 22(3), 467– 484

Zhou, Y. W., Lau, H. S., and Yang, S. L. (2004). A finite horizon lot-sizing problem with time-varying deterministic demand and waiting-time-dependent partial backlogging. *International Journal of Production Economics*, 91(2), 109–119

APPENDIX 1.

```
function y=A(x)
t0=0.340502571826049;
t1=0.584971443459525;
y=(x-t0)*(feval(@g,t1)-feval(@g,x));
function y=f(x)
y=10*x+2*x^2;
function y=g(x)
y=5*x^2+2/3*x^3;
function y=Gc(x)
y=5/3*x^3+1/6*x^4;
function y=h(x)
t0=0.340502571826049;
t1=0.584971443459525;
y=feval(@g,t1)-feval(@g,x)-(x-t0)*feval(@f,x);
function y=R(x)
s0=0;
s1=0.1954138487892830;
y=4*(feval(@g,s1)-feval(@g,x))+(10*0.3*feval(@f,x))-
(10*0.3*feval(@f,x))+(8*0.7*(feval(@g,s0)-feval(@g,x)));

% Sub-problem1_Method2_SampleProblem1
%==============================================================
% Initialization
%===============================================================
c1=9;% Setup Cost
c2=2;% Holding Cost
c3=2.5*c2;% Shortage Cost
%Demand parameters
o=0;
p=900;
q=100;
```

```
r=0;
t(1)=0;% Beginning of horizon
s(1)=1;% End of planning horizon
n(1)=1;% Number of replenishment at initial period
n_add = 1;
%=====================================================================
% Algorithm to find time of replenishment and shortage point
%=====================================================================
while n_add > 0
   r = r+1;
   n_add = 0;
   for i=1:1:n(r)
      t_old =1.0e308;
      t_new= (t(i)+s(i))/2;
      while abs(t_old-t_new)>1.0e-6
         t_old=t_new;
         s_add =((t(i)*c2)+(t_old*c3))/(c2+c3);
         disp (s_add);
         a = s_add;
         b = s(i);
         fa = tz (a,a,b,o,p,q,c2,c3);
         fb = tz (b,a,b,o,p,q,c2,c3);
         while (b-a) > 1.0e-6
            m = (a+b)/2;
            fm = tz (m, s_add, s(i),o,p,q,c2,c3);
            if fa*fm < 0
               b = m;
               fb = fm;
            else
               a = m;
               fa = fm;
            end
         end
         t_new = (a+b)/2;
```

```
        disp (t_new);
        disp (t_old);
      end
      t_opt=(t_old+t_new)/2;
      disp (t_opt);
      c=t(i);
      b=s(i);
      TC1=tc1(c,b,o,p,q,c1,c2);% Evaluating total cost between one and two replenishment
      disp (TC1)
      a=s_add;
      d=t_opt;
      TC2=tc2(a,b,c,d,o,p,q,c1,c2,c3)
      if TC2<TC1
        n_add = n_add+1;
        t(n(r)+n_add) = t_opt;
        s(n(r)+n_add)=s_add;
      end
    end
    n(r+1) = n(r) + n_add;
    B = sort(t);
    t = B;
    disp(t)
    C = sort (s);
    s=C;
    disp (s)
end
%=========================================================================
% Finding Total Inventory Cost
%=========================================================================
TC=0;
for i=1:1:n(r)-1
    holding(i)=W(t(i),s(i),o,p,q);
    shortage(i)=S0(s(i),t(i+1),o,p,q);
    TC=TC+c1+c2*holding(i)+c3*shortage(i);
```

```
end
   holding(n(r))=W(t(n(r)),1,o,p,q);
   TC=TC+c1+c2*holding(n(r));
   disp ('Total cost is:')
   disp (TC)
end
%=============================================================
% Finding Order Quantity
%=============================================================
TO=0;

for i=1:1:n(r)-1
   order(i)=Q(t(i),s(i),o,p,q);
   TO=TO+order(i);
end

last_order(i)=Q(t(n(r)),1,o,p,q);
TotalOrder=TO+last_order;
disp('Quantity orders are')
disp (TotalOrder);

SO=0;
for i=1:1:n(r)-1
   qshortage(i)=S(s(i),t(i+1),o,p,q);
   SO=SO+qshortage(i);
   disp ('Quantity shortages are')
   disp (qshortage);
end
end
```

Filename: FinalReport1_2011
Directory: D:\Dari ACER\Ririn\TriDharmaPT\Penelitian\Penelitian_LPPM\PenelitianLPPM
Template: C:\Users\Ririn\AppData\Roaming\Microsoft\Templates\Normal.dotm
Title: Pengembangan Particle Swarm Optimization dengan Parameter Inertia Weight Adaptif
Subject:
Author: The Jin Ai
Keywords:
Comments:
Creation Date: 6/21/2011 12:36:00 PM
Change Number: 72
Last Saved On: 2/9/2012 9:48:00 AM
Last Saved By: Ririn
Total Editing Time: 1,444 Minutes
Last Printed On: 3/29/2012 1:14:00 PM
As of Last Complete Printing
Number of Pages: 26
Number of Words: 3,773 (approx.)
Number of Characters: 21,507 (approx.)

Message ririn@mail.uajy.ac.id

Folders | Create Message | Preferences | Address Book | Edit Mail Filters | Edit Autoreplies | Log Out

Move to: INBOX Go

« » Message 1 of 4

From: Budi Santosa <shima1907@yahoo.com>
Reply-To: Budi Santosa <shima1907@yahoo.com>
To: "ririn@mail.uajy.ac.id" <ririn@mail.uajy.ac.id>
Date: 29 Sep 2011, 11:42:25 AM
Subject: paper IESS for publication

HTML content follows

Dear Ririn,
As we promised to participants whose papers are quailified for journal pulication, I offer your paper with title Heuristic Algorithm ...Partial Backlog Case and Deterministic Demand to be publsihed in **Operations and Supply Chain Management : An International Journal**. (http://journal.oscm-forum.org/)
Of course your paper will have to follow the regular steps before officially published.

Please send directly your paper to the chief Editor at pujawan@ie.its.ac.id

regards
=======
Budi santosa, PhD
Lab Komputasi and Optimasi Industri,
ITS, Surabaya, Indonesia
http://blog.its.ac.id/bsant

« » Message 1 of 4

Move to: INBOX Go

Proceeding of Industrial Engineering and Service Science, 2011, September 20-21

Heuristic Algorithm Based on Consecutive Method for Inventory Policy with Partial Backlog Case and Deterministic Demand

Ririn Diar Astanti [(1)]; Huynh Trung Luong [(2)]

(1) Department of Industrial Engineering, Universitas Atma Jaya Yogyakarta, INDONESIA, E-mail: ririn@mail.uajy.ac.id
(2) Industrial and Manufacturing Engineering Program, Asian Institute of Technology, THAILAND, E-mail: luong@ait.ac.th

ABSTRACT

Originally, the consecutive method was proposed by Wang [1] to determine inventory policy for the non shortage case. Later on Astanti and Luong [2] extended the work of Wang by developing new algorithm based on consecutive method for shortage case but limited on completely backlog situation. It is noted that the shortage case is the situation when customer arrive but the goods are not there. When all customers are willing to wait until the next replenishment, it is called completely backlog situation. However, in the real situation it often happens that some customers are willing to wait, but the other prefers to find another supply sources, or it is called partial backlog case. The work of this research, therefore, is going to develop the algorithm for determining inventory policy with partial backlog case.

Keywords: *Inventory policy, Heuristic, Consecutive method, Partial backlog*

1. Introduction

Inventory policy deals with "*management of stock level of goods*" [3] and comprises of decisions about when and how much the order/production should be placed. Those decisions are crucial, since a company have to manage its inventory properly in order to meet customer's demands with minimum cost.

Before developing an inventory policy, demand should firstly be estimated. Demand of a particular products itself has either probabilistic or deterministic characteristic. Many researches on inventory policy have been done dealing with probabilistic demand such as [4-12], among others. However, the focus of this research is on deterministic demand. It is noted that if the result of the developed algorithm is promising for the case of deterministic demand, then the developed algorithm will be extended to the case of probabilistic demand.

In reality, the shortage period might occur in each replenishment cycle, e.g., when customer arrives, no stocks of goods are available. From the standpoint of supplier, shortage sometimes is economically preferable, e.g., when holding cost is significant high as compared with shortage cost. The shortage case can be divided into two which are completely backlog and partial backlog cases. The completely backlog case is the situation when customer arrive but the goods are not there, but all customers are willing to wait until the next replenishment. In the partial backlog case, however, some customers are willing to wait, but the other prefers to find another supply sources.

Inventory models with infinite planning horizon of partial backlog case with fixed fraction of backlog had been proposed in [13]. They developed models and solution technique for not only constant demand rate, but also stochastic demand rate, in which covers continuous and periodic review models. The work had been extended by considering customer impatience into the fraction of backlogged demand, in which the backlog fraction is modeled as linear function [14] and general non increasing function [15]. Instead of infinite planning horizon, a finite planning horizon model for this situation [16] developed the heuristic method for SFI policy, not only for linear increasing but also for nonlinear increasing demand.

Based on the research that was done by [2], it shows that the results of heuristic algorithm based consecutive method are comparable to the results of other methods, especially for the case of deterministic demand and completely backlog case. More over that method is easy in concept and computationally simple. The work of this research, therefore are going to develop the algorithm for determining inventory policy with partial backlog case and finite planning horizon. Section 2 of this paper is containing the mathematical model of the inventory model with finite planning horizon of partial backlog case with fixed fraction backlog. Then, the heuristic algorithm based on consecutive method for solving the problem is presented in Section 3. Finally, an example of the application of the heuristic is presented in Section 4.