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An Order Level Inventory Model with Three-Component Demand Rate (TCDR) For A Newly Launched Deteriorating Item

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Abstract**—** Assume a company launches a new item as a minor upgradation in the well established product. For example, shaving cream now mixed with fragrance and pink color. It is new and unknown for users as well as in the market but inventory is maintained. Marketing is continued by variety of plans and let deterioration of item occurs only after a duration. This paper introduces a concept of using Three Component Demand Rate (TCDR) and presents an optimum order level inventory model for newly launched deteriorating item by describing two different constant rates of demand, along with time dependent demand. Optimal cost under model is derived along with optimum time and consumed quantity. Results are illustrated by numerical examples and effectiveness of model parameters is discussed through sensitivity analysis with different graphical presentations. The optimal cost sensitiveness is also incorporated in the paper over varying model parameters. Effect of two marketing strategies and market survey durations are examined. Conditions for marketing plan design are discussed and it is found that marketing plans, if designed carefully, highly affect the optimal parameters of a new product inventory system. It generates the form of approximate linear pattern in optimally derived quantities, time, cost and others.
Keywords**—** Inventory, economic order level (EOL), economic order quantity (EOQ), deterioration, three components demand rate (TCDR).

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1. INTRODUCTION

In the EOQ setup, some authors have attempted to determine the optimum order policy for deteriorating items under varying situations with different rates of demand. Few items in the market are of high need for people like sugar, wheat, oil whose shortage break the customer faith and arrival pattern towards the warehouse. This motivates retailers to order for excess units of item for inventory in spite of being deterioration. Moreover, deterioration is manageable for many items by virtue of modern advanced storage technologies. Some EOQ models in the literature of before decade of ethics do not consider the deterioration factor but researches in recent past realized and incorporated this in EOQ models as a source of esteem importance [see Benkherouf (1995), Chakrabarti and Chaudhari (1997), Donaldson (1997), Gupta and Agrawal (2000), Shukla et al (2009)].

Kumar (2009), as data incorporated in appendix A, has a contribution on the effect of change of marketing strategies over the sale rate of a newly introduced item. Consumer attraction plans are often offered by the product companies time to time designed by data of market surveys. Assume the inception of two marketing strategies in the form of consumer offer plans for promoting the launched item, restricted to a certain period, as shown in fig1 (a) & (b) described below.

Plan A: To provide gift voucher on the purchase of launched product (or item).
Plan B: To provide price rebate (upto a prefixed duration only) and gift voucher both on the purchase of same product.

Marketing plan B seems more attractive than A because of more offered returns to consumer. This may affect the model parameters as expected. One can assume in comparative sense a constant impact due to plan A over a duration and linear time dependent impact of plan B. The PB1 and PB2 are time durations of market surveys to collect data for the assessment of popularity of launched item. The μ_1 and μ_2 are points for time of implementing these plans. To examine the effect of plans in EOQ models motivates for Three Components Demand Rate (TCDR). Some useful contributions to EOQ models are due to Aggrawal and Jain (2001), Basu and Sinha (2007), Gosh and Cha (2004), Goswami and Choudhari (1991), Lin at al. (2000), Srivastava and Gupta (2007).

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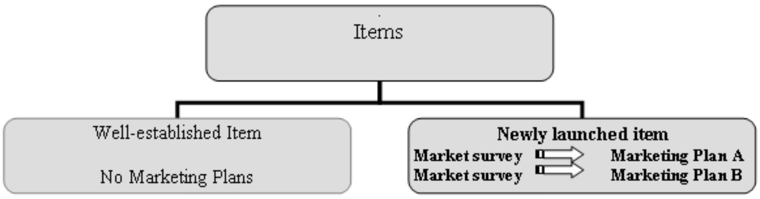

Fig. 1(a): (Item wise marketing plan)

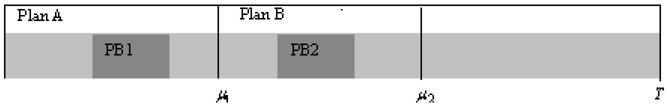

Fig. 1(b): (Market survey and marketing plan implementation)

This paper is for a newly launched item and presents an inventory model with TCDR assuming the implementation of varying marketing plans time to time through surveys. Basic motivation is from survey data attached in the appendix A.

2. NOTATIONS

- $I(t)$: On hand inventory at time.
- q : Number of units of new product (item) at the beginning of time cycle.
- θ : Rate of deterioration of item.
- C_0, C_1, and C_3 : Purchasing Cost per unit, Holding cost, and Set-up Cost respectively.
- $[0, \mu_1]$, $(\mu_1, \mu_2]$ and $(\mu_2, T]$ are three durations of time in cycle T .
- $t_1 = T - \mu_2$ is a time length when deterioration starts with linear growth of demand.
- a , *b, c, d,* are non-zero constants such that $a < b < c$.
- a , b and $[c + d\ (t - \mu_2)]$ are three variants for demand rates over time intervals $[0, \mu_1]$, $(\mu_1, \mu_2]$ and $(\mu_2, T]$ respectively, $\mu_2 < t \le T$.
- T^*, q^* *and* $K(T^*)$ are optimum time, optimum quantity and optimum total cost respectively as usually taken in EOQ models.

2.1 Remark

The constants *a, b, c* denote the fixed demand rate of the launched item over the time duration and *d* denotes the incrementing demand rate per unit time. Like an example, the sale of a cosmetic item increases to 3 units per day ($d = 3$) upto the duration of 30 days only whereas the normal fix sale pattern is 10 units ($c = 10$) everyday. It forms the $c + dt$ pattern of demand for 30 days. For more detail, one can go through fig B1 and others contained in the appendix B.

3. ASSUMPTION AND FORMULATION OF INVENTORY MODEL

Let a businessman has q number of units in stock of a newly launched product (item) in the market. Stock quantity q decreases upto $(q - a\mu_1)$ by constant demand rate '*a*' units (per unit time) in time interval. $[0, \mu_1]$. A market survey PB1 conducted in between $[0, \mu_1]$ for understanding the popularity level and sale pattern of the launched item fig 1(b). Based on survey results a marketing strategy (plan A) is designed and implemented at μ_1 and, because of this, the demand increased to another constant level '*b*' ($b > a$) units (per unit time). Accordingly, the stock quantity units $(q - a\mu_1)$ reduced to $(q - a\mu_1 - b\mu_2)$ until time μ_2 . The item owner company conducted another market survey PB2 during time $(\mu_1, \mu_2]$ and based on report a new marketing policy (plan B) designed and implemented at μ_2 . It was so effective that the constant demand pattern converted into growing time dependent pattern and quantity $(q - a\mu_1 - b\mu_2)$ reduced to zero at the end of cycle *T*. New readjusted demand is $(c + d(t - \mu_2))$ in interval $\mu_2 < t \le T$. The item does not deteriorate until time μ_2 , like cosmetic products remain as it is for longer. Time horizon of the system is infinite and a typical planning schedule of the cycle of length *T* is considered. Holding cost, ordering cost and purchasing cost per unit are assumed constant over T. Shortage of units of item is not allowed and repair (or replenishment) of deteriorated units is not permissible. Some other symbols and notations are stated below:

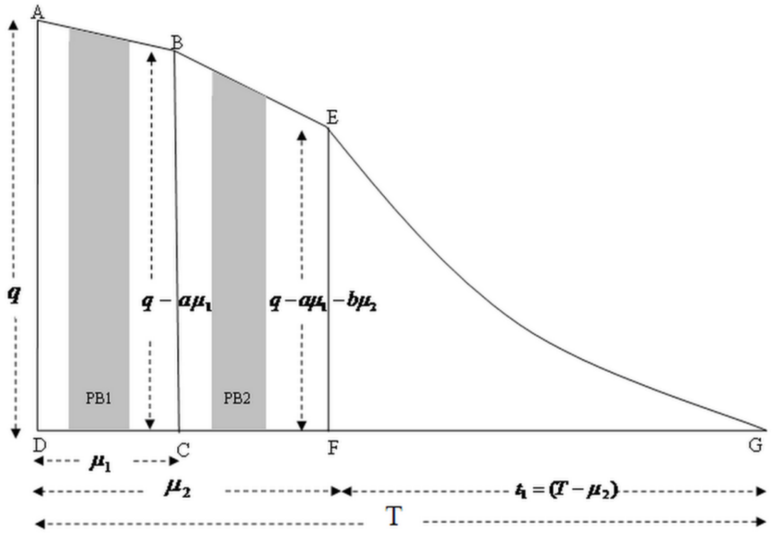

Fig 2: (Inventory system for one time cycle T)

(a): Demand rate in time interval $[0, \mu_1]$ is 'a ' units (per unit time) and total demand in this period $= a\mu_1$

(b): Quantity remains after the period $\mu_1 \;= (q - a\mu_1)$

(c): Holding cost during the period $[0, \mu_1]$ = C1 (Area of trapezium ABCD)

$$= \frac{C_1}{2}\{q + q\text{-}a\mu_1\}\,\mu_1 = C_1\left\{q - a\mu_1 + \frac{a\mu_1}{2}\right\}\mu_1 \tag{1}$$

(d): Due to implementation of marketing strategy A the demand sets to 'b' units per unit time (*b*>*a*) and quantity required between $(\mu_1, \mu_2]$ is $= b(\mu_2 - \mu_1)$

(e): At the end of μ_2, balance of quantities to be consumed in time μ_2 to T are:
$= [q - a\mu_1 - b(\mu_2 - \mu_1)]$.

(f): Holding cost during $(\mu_1, \mu_2]$ = C1(Area of trapezium BCEF)

$$= C_1\left(q - a\mu_1 - b(\mu_2 - \mu_1) + \frac{b(\mu_2 - \mu_1)}{2}\right)(\mu_2 - \mu_1) \tag{2}$$

(g): The $I(t)$ is quantity of launched item at time t in the system and θ is rate of deterioration of units of item starting from μ_2. After the market research and implementation of modified marketing plan B the demand depends on time in the form $[c + d\,(t - \mu_2)]$.

Differential equation of $I(t)$ and demand for $(\mu_2, T]$ is:

$$\left[\frac{d}{dt}I(t) + \theta\ \mathrm{I(t)}\ \right] = -\{c + d\,(t - \mu_2)\},\ where\ \ \mu_2\ \le t \le\ T \tag{3}$$

with boundary conditions $t = 0, I(0) = [q - a\mu_1 - b(\mu_2 - \mu_1)]$ and $t = t_1 = [T - \mu_2]$, $I(t_1) = 0$

The solution of (3) is $I(t)\mathrm{e}^{\theta\, t} = -\int_0^{\mathrm{t}} \mathrm{e}^{\theta\, t}\{c + d\,(t - \mu_2)\}\,dt + A$ (4)

where A is integral constant evaluated by applying boundary condition $t = 0,\ I(0) = [q\text{ - }a\mu_1 - b(\mu_2 - \mu_1)]$.

We get $A = [q\text{-}a\mu_1\text{-}b(\mu_2\text{-}\mu_1)]$ and substituting A in equation (4)

$$I(t)\mathrm{e}^{\theta\, t}\text{-}\{q\text{-}a\mu_1 - b(\mu_2 - \mu_1)\} = -\int_0^{\mathrm{t}} \mathrm{e}^{\theta\, t}\{c + d\,(t - \mu_2)\}\,dt$$

By boundary condition $t = t_1 = T - \mu_2,\ I(t_1) = 0$, we get

$$[q\text{-}a\mu_1 - b(\mu_2 - \mu_1)] = \int_0^{\mathrm{t_1}} \mathrm{e}^{\theta\, t}\{c + d\,(t - \mu_2)\}\,dt$$

$$[q\text{-}a\mu_1 - b(\mu_2 - \mu_1)] = \int_0^{\mathrm{t_1}}\{\ c + d\ \ (t - \mu_2)\}\sum_{n=0}^{\infty}\frac{\theta^n\ t^n}{n!}dt \tag{5}$$

Since the deterioration rate is generally very small due to modern technically advanced storing facilities, the higher power $(n > 1)$ over θ is negligible and one gets

$$q - a\mu_1 - b(\mu_2 - \mu_1) = (c - d\mu_2)\left(t_1 + \frac{\theta t_1^2}{2}\right) + d\left(\frac{t_1^2}{2} + \frac{\theta t_1^3}{3}\right) \tag{6}$$

(h): Due to deterioration the curve in fig. 2 in time interval $(\mu_2, T]$ is not a straight line. However, the derivation of holding cost obtained assuming no deterioration (treating straight line) just to avoid mathematical complexities. The similar approach fallowed by Gosh and Cha (2004), Srivastava and Gupta (2007) but not for a newly launched item with varying marketing plans. Their approach is suitable for only the inventory of well established and well-known item in the market.

(i):Holding cost during the period $(\mu_2, T]$ is $= \dfrac{C_1}{2}(q - a\mu_1 - b(\mu_2 - \mu_1))t_1$ (7)

(j): Let deteriorated units of item in system during $(\mu_2, T]$ is D then

$$D = [q\text{-}a\mu_1 - b(\mu_2 - \mu_1)] - \int_0^{t_1} [c + d(t - \mu_2)]dt$$

$$= q\text{-}a\mu_1 - b(\mu_2 - \mu_1) - (c - d\mu_2)t_1 - \frac{d\, t_1^2}{2} \tag{8}$$

(k): Deterioration cost in period $(\mu_2, T]$ is $= (C_0 . D)$

$$= C_0\left\{q\text{-}a\mu_1 - b(\mu_2 - \mu_1) - (c - d\mu_2)t_1 - \frac{d\, t_1^2}{2}\right\} \tag{9}$$

(l): Average inventory cost $K(T)$ is

$$K(T) = \frac{1}{T}\left[\begin{array}{l} holding\ \text{cost}\ for\ period[0, \mu_1] + holding\ \text{cost}\ for\ period(\mu_1, \mu_2] \\ + holding\ \text{cost}\ for\ period(\mu_2, T] + Deteriorating\ \text{cost} + \text{Setup cost} \end{array}\right]$$

Substitute values of holding cost in different periods from equations (1), (2), (7) and deteriorating cost from (9) in above equation.

$$K(T) = \frac{1}{T}\left[C_1\left(q - a\mu_1 - b(\mu_2 - \mu_1) + \frac{a\mu_1}{2} + b(\mu_2 - \mu_1)\right)\mu_1\right] + \frac{1}{T}\left[C_1\left(q - a\mu_1 - b(\mu_2 - \mu_1) + \frac{b(\mu_2 - \mu_1)}{2}\right)(\mu_2 - \mu_1)\right]$$

$$+ \frac{1}{T}\left[\frac{C_1}{2}(q - a\mu_1 - b(\mu_2 - \mu_1))\right]t_1 + \frac{1}{T}\left[C_0\left\{q - a\mu_1 - b(\mu_2 - \mu_1) - (c - d\mu_2)t_1 - \frac{d\, t_1^2}{2}\right\} + C_3\right] \tag{10}$$

As per Fig. 2, the time period $t_1 = (T - \mu_2)$ and substitute this in equation (10).
Briefly, one can express in simplified form:

$$K(T) = \frac{1}{6T}\left[2\alpha T^4 + 3\beta T^3 + 6\gamma T^2 + 6\lambda T - 6\eta\right] \quad (11$$

where $\alpha = \dfrac{C_1 d\theta}{2}$

$$\beta = \frac{1}{6}\left[4d\theta C_0 + 3c\, C_1\theta + 3C_1 d - 7C_1 d\theta\mu_2\right]$$

$$\gamma = \frac{1}{4}\left[C_1 d\theta\mu_2^2 - (6\theta C_0 d + \theta c C_1 - 3C_1 d)\mu_2 + 2\theta\ c\, C_0 + 2cC_1\right]$$

$$\lambda = \frac{1}{12}\left[7C_1 d\theta\mu_2^3 + (24\theta C_0 d - 3\theta c C_1 - 3C_1 d)\mu_2^2 - 12\theta\ c\, C_0\mu_2\right]$$

$$\eta = \frac{1}{12}\left[5C_1 d\theta\mu_2^4 + \{10d\theta\, C_0 - 3c\theta C_1 - 9dC_1\}\mu_2^3 + \{6\, c\, C_2 - 6c\theta C_0\}\mu_2^2\right]$$

$$-\left[\mu_1 C_1\left\{\frac{a\mu_1}{2} + b(\mu_2 - \mu_1)\right\} + \frac{C_1 b}{2}(\mu_2 - \mu_1)^2 + C_3\right]$$

Optimal condition by (11) gives the equation of T.

$$\frac{dK(T)}{dT} = 0 \Rightarrow \left[\alpha T^4 + \beta T^3 + \gamma T^2 + \delta T + \eta\right] = 0, \text{ where } \delta = 0 \tag{12}$$

One can solve above biquadrate equation of T and let the positive optimal solution value is T^* and further second differential $\dfrac{d^2K(T)}{dT^2} > 0$, holds for $\mu_1 < \mu_2 < T^*$ and $C_1 < C_0 < C_3$. At point T^* the optimum level of quantity is q^*, optimum deteriorated units are D* and optimum total cost is *K(T*)* respectively as expressed below;

$$q^* = a\mu_1 + b(\mu_2 - \mu_1) + (c - d\,\mu_2)\left\{(T^* - \mu_2) + \frac{\theta(T^* - \mu_2)^2}{2}\right\} + d\left\{\frac{(T^* - \mu_2)^2}{2} + \frac{\theta(T^* - \mu_2)^3}{3}\right\} \tag{13}$$

$$D^* = q^* - a\mu_1 - b(\mu_2 - \mu_1) - (c - d\mu_2)(T^* - \mu_2) - \frac{d(T^* - \mu_2)^2}{2} \tag{14}$$

$$K(T^*) = \frac{1}{6T}\left[2\alpha T^{*4} + 3\beta T^{*3} + 6\gamma T^{*2} + 6\lambda T^* - 6\eta\right] \tag{15}$$

4. SENSITIVE ANALYSIS

It is based on examining effects by changing one model parameter while others remain constant over time duration. The μ_1 is time point when demand rate is low and no market plan implemented. Similarly, μ_2 is time point when preliminary marketing is over for the item. Increment in μ_1 delays the implementation of plan A and increment in μ_2 delays the implementation of plan B. So, plan A and B both are linked with the μ_1 and μ_2 parameters of the suggested model.

4.1 EFFECT OF μ_1 ON OUTPUT

Table 2: Effect of parameter μ_1 on output

Invariant parameters	μ_1	T^*	D^*	q^*	$K(T^*)$
$a=10, b=0, C_3=100$, $d=10$, $\theta=0.05$, $C_0=18$, $C_1=0.4$	0.2	1.1382	0.643	28.62	155.38
	0.3	1.1578	0.509	26.06	149.48
	0.4	1.1784	0.397	23.77	143.46
	0.5	1.2009	0.303	21.78	137.44
	1.0	1.3741	0.061	16.37	111.55

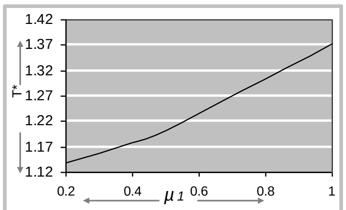

Fig. 3: (Effect on T* due μ1)

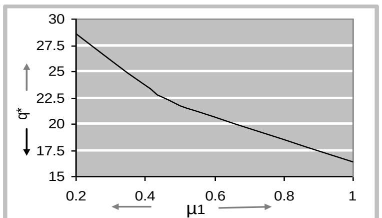

Fig. 4: (Effect on q* due to μ1)

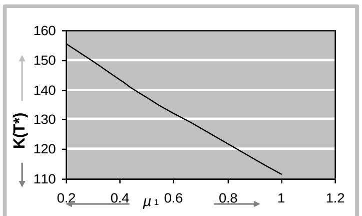

Fig.5: (Effect on K(T*) due to μ1)

4.2 EFFECT OF $\mu = (\mu_2 - \mu_1)$ ON OUTPUT (μ_1 fixed)

Table 3: Effect of parameter $\mu = (\mu_2 - \mu_1)$ on output (μ_1 fixed)

Invariant parameter	$\mu = (\mu_2 - \mu_1)$	T^*	q^*	$K(T^*)$
$a=0$, $b=20$, $d=10$, $\theta=0.05$, $C_0=7, C_1=0.4$ $C_3=100$	0.5	1.2167	24.22	140.09
	0.75	1.3182	23.73	130.59
	0.9	1.3982	24.33	126.44
	1.5	1.8804	31.57	121.99

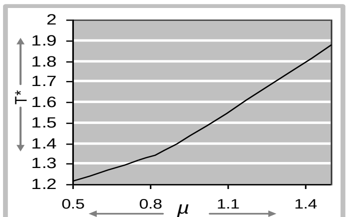

Fig. 6: (Effect on T* due μ)

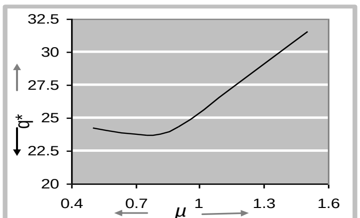

Fig. 7: (Effect on q* due to μ)

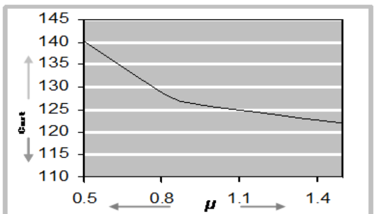

Fig.8: (Effect on K(T*) due to μ)

4.3 EFFECT OF UNIT PURCHASING COST (C_1) ON OUTPUT

Table 4: Effect of parameter C_0 on output

Invariant parameter	C_0	T^*	q^*	$K(T^*)$
$a=10, b=20$ $\theta=0.02$ $d=0.2,\quad c=25$ $C_0=7,\quad C_3=100$	8	0.9583	20.02	196.36
	6	1.1063	23.77	171.73
	5	1.2100	26.41	157.70
	4	1.3480	29.94	142.09

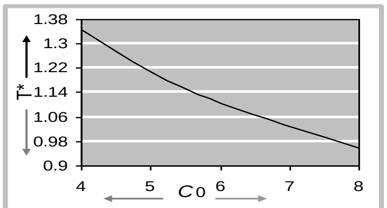

Fig. 9 :(Effect on T* due to C_0)

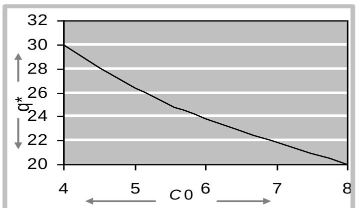

Fig. 10: (Effect on q* due to C_0)

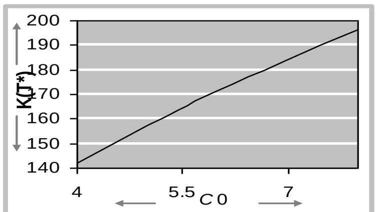

Fig. 11: (Effect on K(T*)due to C0)

5. EFFECT OF MARKETING PLANS

In this section we observe the effect of plan A and plan B over optimality. Implementations of plan A starts at time μ_1 and plan B starts at μ_2 . Plan A also relates to model parameter *b* while plan B with parameters c and *d* both. Since $b>0$, $c>0$, $d>0$ and $b>c$ holds in basic assumptions, it is logical to examine the effect of varying positive values of these constants over optimal expressions T^*, q^* and $K(T^*)$.

5.1 EFFECT OF MARKETING PLAN A

Table 5: Effect of Plan A on output

Invariant parameters	b	T^*	D^*	q^*	$K(T^*)$
$a=40, c=70$ $d=0.2, \theta=0.2$ $\mu_1=0.4, \mu_2=0.8$ $C_0=20, C_1=0.7$	45	0.99312	0.261	47.75	104.37
	50	0.99558	0.267	49.93	105.21
	60	1.00056	0.281	54.29	106.86
	70	1.00303	0.288	56.47	107.74

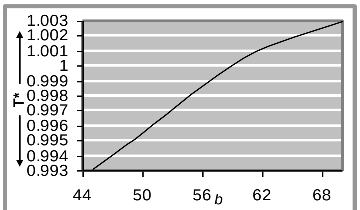

Fig. 12: (Effect of plan A on T*)

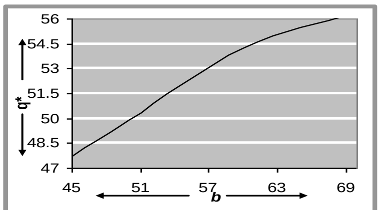

Fig. 13: (Effect of plan A on q*)

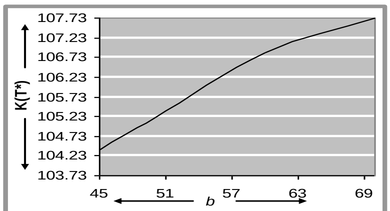

Fig.14 : (Effect of plan A on K(T*))

5.2 EFFECT OF MARKETING PLAN B

Table 6: Effect of Plan B (*c*) on output (where *d* fixed)

Invariant parameters	c	T^*	D^*	q^*	$K(T^*)$
$a=40, b=45$ $d=5, \theta=0.1$ $\mu_1=0.4, \mu_2=0.5$ $C_0=18, C_1=0.5$	60	1.8868	0.5973	105.65	76.43
	80	1.6572	0.5447	114.08	86.24
	90	1.5668	0.5181	117.21	90.59
	120	1.3614	0.4466	124.02	101.98
	150	1.2150	0.3831	127.62	111.48

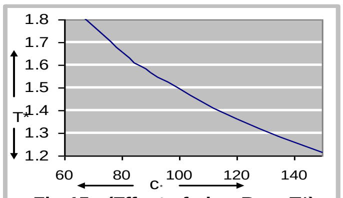

Fig.15 : (Effect of plan B on T*)

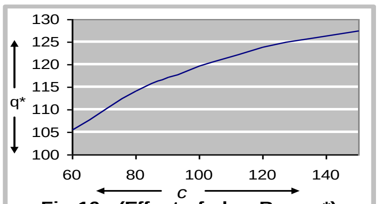

Fig.16 : (Effect of plan B on q*)

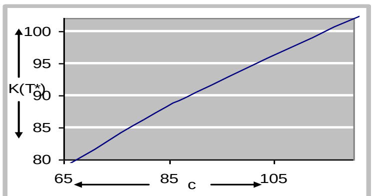

Fig.17 : (Effect of plan B on K(T*))

5.3 EFFECT OF MARKETING PLAN B

Table 7: Effect of Plan B (*d*) on output (where *c* fixed)

Invariant parameters	d	T^*	D^*	q^*	$K(T^*)$
$a = 40, b = 45\ c = 60,$	0.5	1.8130	0.605006	113.12	81.11
$\mu_1 = 0.4, \mu_2 = 0.5, \theta = 0.1$	1	1.8081	0.602076	112.87	81.17
	5	1.7621	0.571115	110.25	81.53
$C_0 = 18, C_1 = 0.5$	20	1.6406	0.489225	102.44	82.52

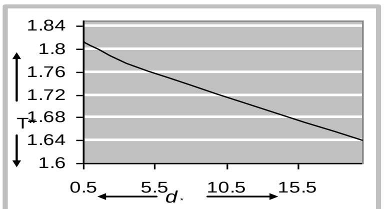

Fig.18 : (Effect of plan B on T*)

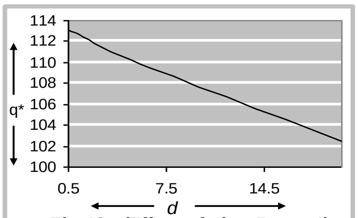

Fig.19 : (Effect of plan B on q*)

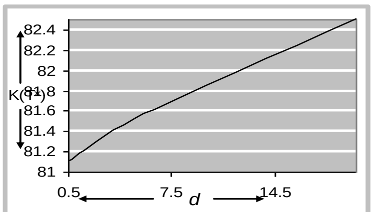

Fig.20 : (Effect of plan B on K(T*))

6. RESULT AND DISCUSSION

This is to note from table 2,

- Optimal time is sensitive over parameter μ_1 [see fig 3].
- Optimal quantity q^* is adverse sensitive on μ_1 which means if time component $[0, \mu_1]$ increases, the consumption of number of units decreases [see fig 4]. The longer market survey duration PB1 affects the optimality level of quantity.
- Since q^* is adverse on μ_1, optimal cost $K(T^*)$ is also adverse sensitive over μ_1 [see fig 5]. The PB1 should start as early as possible and finish over at an early reasonable duration.

Inventory analysis suggests to keep changing the marketing policy regularly in order to keep increasing the consumption level of quantity. A careful examination of table 3 reveals:

- Optimal time is highly sensitive over parameter μ [as in fig 6].
- Optimal quantity q^* is partially sensitive on μ [see in fig 7]. The PB2 duration should be shorter to restrict the μ a reasonable length.
- Optimal cost $K(T^*)$ is less sensitive on parameter μ [see in fig 8].

Management group of inventory is suggested to change the plan A to B after an adequate duration to push up the consumption of quantity of launched item. This is to observe from table 4,

- Optimal time T* is adverse sensitive on parameter C_0 [see fig (9)].
- Optimal quantity q^* increases when unit purchasing cost decreases which obeys the law of low cost high volume [see fig 10].
- Optimal cost $K(T^*)$is highly sensitive on C_0 [see fig 11].

In view of fig 12-14, the plan A which relates to parameter b also has growing effect over T^*, q^* and $K(T^*)$. All these are showing nearly linear growth pattern over increasing b. Marketing plan A has significant impact over the suggested inventory system of newly launched item (since $b > a$ holds). Looking at table 6 and 7, one can find that

- T^* is adverse sensitive by varying *c, d* [see fig 15 & 18].
- q^* is sensitive for *c* but adverse for *d* [see fig 16 & 19].
- $K(T^*)$ is sensitive for both *c* and *d* [see fig 17 & 20].

The overall incrementing variations of *c, d* affect the optimality level of output. The second plan B, if implemented at the right point of time μ_2 , certainly and significantly produces positive impact on the optimality of suggested inventory model for new item. To note that plan A and plan B are to be designed intelligently and carefully by survey data in such a way that basic conditions $c > b > a > 0$ & $d > 0$ must hold. The approximate linear growth or linear decay has been found in almost all graphical relationships with optimal *T*, *q* and *K*(*T*) quantities over varying *b, c & d* which is an interesting feature related to planning and prediction of inventory of new item.

7. CONCLUDING REMARK

Inventory model for an established item differs from the model of a newly launched item in the sense that market surveys and making plans implementation are the essential and integral part of the later one. Most of existing literatures in the area of inventory models are for the established item only. The launched item constantly suffers from repeated market surveys and changing marketing plans for sale promotion. Often new item disappears from the market if not liked by customers (which is not for established item). The start and finish up duration of a market survey, marketing plan design and plan implementation time point are the vital aspects to be taken into consideration by the inventory managers and producing companies. The debatable matter is what should be an ideal survey duration, how to design a plan for promotion, when to implement that plan, when to start next market survey and when to stop it?

Marketing strategies are generally designed based on collected data during market surveys for the launched item. The power of a well designed marketing plan affects the optimal demand level and optimal quantity consumption pattern. As per suggested model, if market survey durations are longer, the time points of plan implementation are also long. These provide adverse effect on the optimal quantity consumption level. The plan A if designed carefully, based on survey data, produces positive effect on the consumed quantities and optimal cost both if implemented at an early reasonable time point. Next plan B also has positive effect on the consumption of quantities and optimal cost. It is recommended for inventory managers to keep duration of market surveys as shorter as possible to maintain the length μ_1 and μ_2 reasonable. Moreover, market surveys and market plans both, if designed carefully and implemented at the appropriate time produce positive impact on the consumption of units of newly launched item. If there are many marketing plans designed based on the same survey data, it is advised to managers to choose only that one maintaining $c > b > a > 0 \,\&\, d > 0$ parametric relation standards towards the high value level. The approximate linear relationship with these to the optimal parameters makes a way for easy prediction about the inventory item.

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Appendix A (Source: Kumar (2009))

Comparative Sale Data from Retail Market for Established and Newly Launched Commodities

A market survey of five new brand commodities A, B, C, D,E is performed over three occasions in a year with the implementation of new marketing strategies every time. The old and well-established brands of same items are AA, BB, CC, DD, and EE respectively. Actual name of items are kept confidential due to legal bindings. For example AA= popular soap, A= upgraded form of popular soap AA of the same company launched recently.

Number of units sold in month (Feb, 08)	**New Brand Commodities**					**Established Brand Commodities**				
	A	B	C	D	E	AA	BB	CC	DD	EE
	12	18	11	06	05	81	66	77	56	42

The marketing plan is launched after a month of survey and continued up to two months. After this, the sale pattern of same commodities, from same market, are recorded.

Number of units sold in month (May, 08)	**New Brand Commodities**					**Established Brand Commodities**				
	A	B	C	D	E	AA	BB	CC	DD	EE
	18	24	29	18	12	76	63	71	58	43

Another marketing plan is implemented after observing sub-standard growth rate of sale of new brand products. The effect of this plan is in data of sale of Nov. 08.

Number of units sold in month (Nov, 08)	**New Brand Commodities**					**Established Brand Commodities**				
	A	B	C	D	E	AA	BB	CC	DD	EE
	38	32	40	35	27	71	55	70	60	42

It seems the second plan is more effective than first in terms of increasing sale pattern of new brand commodities.

Appendix B [Demand Pattern]

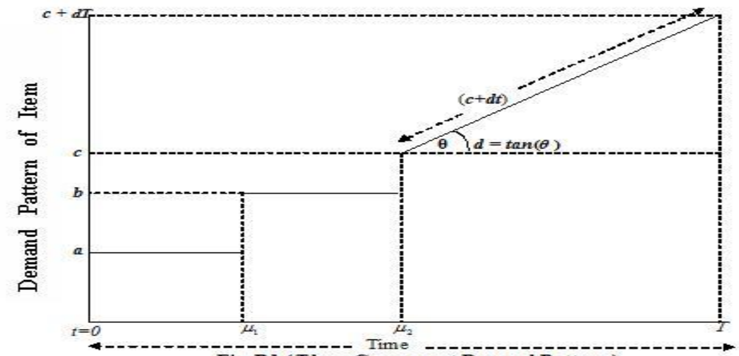

Fig. B1 (Three Component Demand Pattern)

a = Demand rate of units of item in $[0, \mu_1]$,

b = Demand rate of units of item $(\mu_1, \mu_2]$,

c = Demand at time point μ_2 (at the implementation of Plan B)

d = Incrementing demand rate for item per unit time.

An Example:

Out of 365 days in a financial year, the Income Tax Department of a country in a region observed the submission of r_1 tax returns (say $r_1 = 10$) per day. The last date of filling return is declared as **July 31**. Then, two months before, in the month of May and June, the rate of return submission increased to r_2 (say $r_2 = 25$) per day. In the very last month, July, 01, the rate suddenly jumped to r_3 returns (say $r_3 = 38$) per day. While closer to the last date, the return filing rate increased by r_4 (say $r_4 = 2$) every day. This reveals a new rate of return submission specially for the last month , as $(r_3 + r_4 t)$ per day where $t = i$ and i=1,2,3 …stands for ith day of the July month, $i = 31$ denotes the last date.

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