OPTIMAL ORDERING POLICIES UNDER CONDITIONAL TRADE-CREDIT FOR RETAILER

Nita H. Shah[1], Ekta Patel and Kavita Rabari
Department of Mathematics, Gujarat University, Ahmedabad - 380009, Gujarat, India

ABSTRACT
In order to obtain a competition advantages, the proffer of delay payment is of great consequence tool to attract new customers. As a result, in this article, we develop an inventory model for the retailer in which supplier allows a certain fixed period to settle the amount. During this credit period if the retailer pays the outstanding amount by the grace period i.e. first credit period then supplier does not charge any interest. If the amount paid after first credit period, then supplier charge the interest with some interest rate on unpaid balance. If the retailer pays after second permissible credit period, then retailer have to pay interest with extra rate which is more than the first interest rate. Moreover, retailer can earn interest on the revenue during the credit period. An attempt has been made to maximize the total profit in this inventory model under permissible delay in payments. A numerical example is demonstrated the applicability of the model and sensitivity analysis shows the influence of key parameters.

KEYWORDS: Stock-dependent price-sensitive demand, Trade-credit, optimization

MSC: 90B05

RESUMEN
Para obtener ventajas de competencia, el ofrecimiento de demora en el pago es una herramienta de gran consecuencia para atraer nuevos clientes. Como resultado, en este artículo, desarrollamos un modelo de inventario para el minorista en el que el proveedor permite un cierto período fijo para liquidar la cantidad. Durante este período de crédito, si el minorista paga la cantidad pendiente por el período de gracia, es decir, el primer período de crédito, el proveedor no cobra ningún interés. Si el monto se paga después del primer período de crédito, entonces el proveedor cobra intereses con alguna tasa de interés sobre el saldo impago. Si el minorista paga después del segundo período de crédito permitido, entonces el minorista debe pagar intereses con una tasa adicional que es mayor que la primera tasa de interés. Además, el minorista puede ganar intereses sobre los ingresos durante el período de crédito. Se ha intentado maximizar el beneficio total en este modelo de inventario bajo un retraso permisible en los pagos. Se demuestra un ejemplo numérico de la aplicabilidad del modelo y el análisis de sensibilidad muestra la influencia de los parámetros clave

PALABRAS CLAVE: demanda dependiente y sensitiva al precio de las existencia , crédito de negociación, optimización

1. INTRODUCTION

Traditional models are based on the implicit assumption that the payment will be made to the supplier for goods instantly after receiving the deliveries. However, in day-to-day business transaction dealing, it is more and more common to see that the suppliers allow retailer to pay later, that is the trade credit period. Before the end of the trade credit period, the retailer can sell the goods and accrue the revenue and earns interest. Furthermore, the supplier is willingto offer the retailer a definite credit period without interest and after thatcharged the interest with some interest rate under the previously agreed terms and conditions. Therefore, it makes economic sense to retailer that retailer can have some delay of time to settle down the amount of the permissible period hence it is likely to attract more customers because paying later indirectly reduce the purchase cost. This type of strategy is also beneficial to supplier like: trade credit is not only inspiring the customers to order more but also motivate new customers and it can be the alternative of price discount. Hence, the supplier often uses this type of policies to promote his commodities.

2. LITERATURE SURVEY

In optimal inventory system the effect of permissible delay in payments has observed by many researchers from the work of Goyal (1985), he established a single item inventory model under condition of permissible delay in payment and from this article he conclude that order quantity and replenishment cycle is marginally increasing under delay payment. After that Chung and Ward (1987) analyzed Goyal's model by considering

[1]Corresponding author: Nita H. Shah ;E-mail: nitahshah@gmail.com, ektapatel1109@gmail.com, kavitagalchar1994@gmail.com

classical economic order quantity model finding different results.Shah (1993) developed an inventory model for deteriorating items, deteriorated with a constant rate over a time with permissible delay in payments. Then Aggarwal and Jaggi (1995) extended Goyal's (1985) model for deteriorating items. Jamal *et al.* extended Aggarwal and Jaggi's (1995) model by allowing shortages. To modify Shah's (1993) solution, Chung (2000) derived an alternative approach for delay payment. Chung *et al.* (2001) extended this issue by keeping constant demand rate is relaxed and taking linear trended demand. Teng *et al.* (2005)proposed an EOQ model with permissible delay in payments by considering the difference between the selling price and purchase cost. Huang (2003) investigated an EOQ model in which supplies offers a credit period M to retailer and retailer provides credit period N (with $N \le M$) to customers. Liao (2008) developed an inventory model to determine the optimal ordering policies under trade credit of type "α / M net T". Goyal *et al.* (2006) established an EOQ model for the retailer when supplies offera progressive interest charge and give easy-to-used closed form solution. Chang *et al.* (2010) derived an inventory model for buyer using discounted cash flow method. Chung *et al.* (2013) investigated the EOQ model with permissible delay in payment, keeping selling price and purchase cost are equal. Chung *et al.* (2014) established an EPQ inventory model of deteriorating item under two level of trade credit in which supplier gives credit period to retailer and retailer in turns gives maximal credit period to its customer. Soni and Shah (2008) discovered an inventory model under progressive payment scheme in which demand is partially stock dependent. Shah and Barron (2015) explored an inventory model for deteriorating items in which supplier offers order-linked credit period. Chung *et al.* (2014) proposed an inventory model for discounted cash flow approach under trade credit in supply chain. Chung *et al.*(2018) present a combination of quantity discount, trade credits and cash discounts in order to investigate an inventory model when the cash discount depends upon the ordering quantity and time for retailer and customer respectively. Jaggi *et al.* (2017) developed two ware-house inventory model by considering the imperfect production, deterioration and trade credit. Liao *et al.* (2018) analyzed mathematical analytical technique in which optimal ordering strategy is determined for retailer under trade credit policy of two level.

3. ASSUMPTION AND NOTATIONS

3.1. Notations

The following notations are used to develop the inventory model.

Table 1 Parameters table

Parameters	Parameters description
$R(S,I(t))$	Demand rate per year
$I(t)$	Inventory level at time t
α	Scale demand (in units)
β	Mark-up for stop display
η	Price elasticity, $\eta > 1$
h	Holding cost ($/unit/year)
A	Ordering cost per lot ($/lot)
C	Purchase cost per unit ($/unit)
S	Selling price per unit ($/unit), $S > C$
M	First allowable credit period with extra charges
N	Second allowable credit period with extra charges, $N > M$
I_{C_1}	Interest charged $\lvert \$ \rvert$ year by supplier when retailer pays during $[M,N]$.
I_{C_2}	Interest charged $\lvert \$ \rvert$ year by supplier when retailer pays during $[N,T]$, where $I_{c_2} > I_{c_1}$.
I_e	Interest earned $\lvert \$ \rvert$ year and $I_{C_1} > I_e$
I_1	Interest rate if retailer pays during $[M,N]$

I_2	Interest rate if retailer pays during $[N,T]$
T	Cycle time
TP	Profit of the system per unit time
W_1	$\frac{S}{C}M+\frac{SI_e}{2C}N^2$
W_2	$\frac{S}{C}M+\frac{SI_e}{2C}\left(M^2+(N-M)^2\right)$

3.2. Assumptions

The following assumptions are made to develop the inventory model.

I) The market demand of the item is assumed to be price sensitive and is defined as $R(S,I(t))=(\alpha+\beta I(t))S^{-\eta}$, where $\alpha>0$ is a scale demand, $\eta>1$ is index of price elasticity and β denotes mark-up for stop display.

II) Shortages are not allowed.

III) Replenishment rate is infinite.

IV) Time horizon is infinite.

V) The supplier offers trade credit to retailer in this manner:

If the retailer pays before or on M in case of $T<M$, the supplier does not charge any interest to retailer and retailer earns interest on the sales revenue up to the permissible credit period M .If the retailer pays after M but before N, then supplier charges the interest with the interest rate I_1 on the unpaid balance.If the retailer pays after N, then supplier charges interest on the unpaid balance with interest rate I_2, where $I_2>I_1$.

4. MATHEMATICAL MODEL

The inventory level $I(t)$ depletes gradually because of demand is getting satisfied and hence the rate of change of inventory with respect to time can be expressed by the following differential equation.

$$\frac{dI(t)}{dt}=-R(S,I(t)),\quad 0\le t\le T \tag{1}$$

With the boundary conditions $I(0)=Q$ and $I(T)=0$

By solving the diff. equation (1), the inventory level at time t is $I(t)=\frac{\alpha}{\beta}\left[e^{\beta S^{-\eta}(T-t)}-1\right]$ (2)

As a result, the retailer's order quantity is $Q=I(0)=\frac{\alpha}{\beta}\left\{e^{\beta S^{-\eta}T}-1\right\}$ (3)

The total relevant cost per year comprises the following components:

Cost of placing orders: $OC=\frac{A}{T}$ (4)

Cost of carrying inventory: $HC=\frac{h}{T}\int_0^T I(t)dt$ (5)

Sales revenue: $SR=\frac{(S-C)}{T}\int_0^T(\alpha+\beta I(t))dt$ (6)

Regarding interest charged and interest earned, based on the length of replenishment cycle T, we have following possibilities:

Case (I) $T < M$ (i.e. credit period is not less than T)

In the beginning, the retailer has $Q = RT$ units in total at time T. Retailer has to pay CQ units without interest to supplier, so that the interest payable in each order cycle is zero. During $[0,M]$, the retailer sells products and earns interest from sales revenue. Now, we have two possibilities to earn interest.

(a) During $[0,T]$, the interest earned is given by $I_{e_{11}} = \frac{SI_e}{T}\int_0^T R(S,I(t))dt$ (7)

(b) During $[T,M]$, the interest earned is $I_{e_{12}} = \left(SI_e\alpha S^{-\eta}T + \frac{SI_e^{\,2}\alpha S^{-\eta}T^2}{2} \right)(M-T)$ (8)

So the total interest earned per year is given by

$$I_{E_1} = \frac{\frac{SI_e\alpha\left(e^{\beta T}-1\right)}{\beta} + \left(SI_e\alpha T + \frac{1}{2}SI_e^{\,2}\alpha T^2 \right)(M-T)}{T} \tag{9}$$

From (4) to (8), the total profit relevant to cost per year is given by

$$TP_1 = \frac{1}{T}\left\{ SR - \left(OC + HC + I_{C_1} - I_{E_1} \right) \right\} \tag{10}$$

Case (II) $M < T \le W_1$

In this case, the retailer has sufficient balance to settle the total purchase cost at time M and the retailer start to pay off the balance, so there is no interest to pay. Here, there is three possibilities to discuss for interest earned.

(a) During $[0,M]$, the retailer sells the products and earns interest from average sales revenue, so the earned interest is $I_{e_{21}} = \frac{SI_e}{T}\int_0^M Rtdt$ (11)

(b) During $[M,T]$, the retailer still earns interest on the average sales revenue by selling the products until the end of the replenishment cycle time and is given by

$$I_{e_{22}} = \frac{SI_e}{T}\int_0^{T-M} Rtdt \tag{12}$$

(c) After that retailer earns interest from sales revenue and interest earn is given by

$$I_{e_{23}} = \left[\frac{SI_e\alpha S^{-\eta}M}{T} + \frac{SI_e}{T}\int_0^M \alpha S^{-\eta}tdt - CQ \right](T-M) \tag{13}$$

From equation (11) to (13), the total earned interest in this case is $I_{E_2} = I_{e_{21}} + I_{e_{22}} + I_{e_{23}}$ and total profit is

$$TP_2 = \frac{1}{T}\left\{ SR - \left(OC + HC + I_{C_2} - I_{E_2} \right) \right\}$$

Case (III) $W_1 < T < W_2$

In this case, since $W_1 < T$ the total purchase cost is more than the retailer's stored sales revenue at time M. After that, the supplier starts to charge retailer for the unpaid balance with interest rate I_1 at time M then from constant sales the retailer starts to pay the loan and reduce the amount of loan and try to pays off the total purchase cost before N. Now, the interest charged only on unpaid balance with interest rate I_1 at time M, which is given by $U_1 = CQ - S\int_0^M Rdt - SI_e\int_0^M Rtdt$ (14)

As a result, the interest payable per year is given by $I_{C_3} = \frac{U_1^2 I_1}{2ST}\left(T^2 - M^2\right)$ (15)

Consequently, there is two possibilities for interest earned.

Firstly, during $\left[0, M\right]$, the retailer earns interest from average sales revenue and is given by

$$I_{e_{31}} = \frac{SI_e \alpha S^{-\eta} M^2}{2T} \quad (16)$$

Secondly, selling process is continuously on, so interest can be earned and also use revenue to earn interest is given by $I_{e_{32}} = \frac{SI_e \alpha S^{-\eta}}{2T} \frac{\left[T - M - \left(CQ - S\int_0^M \alpha S^{-\eta} dt\right) - S\int_0^M \alpha S^{-\eta} tdt\right]}{SQ}$ (17)

So, the total interest earned is $I_{E_3} = I_{e_{31}} + I_{e_{32}}$

Total profit in this case is $TP_3 = \frac{1}{T}\left\{SR - \left(OC + HC + I_{C_3} - I_{E_3}\right)\right\}$

Case (IV) $W_2 < T$

In this case, the retailer has not sufficient balance to pay off the total purchase cost at time M but the retailer can pay off the total purchase cost before or on N and the supplier starts to charge interest on unpaid balance with interest rate I_1 during the interval $\left[M, N\right]$ and the retailer has unpaid balance is

$$U_2 = U_1 - \int_0^T RS\left(N - M\right)dt + SI_e\int_M^N Rtdt \quad (18)$$

So the supplier starts to charge interest on unpaid amount U_2 with interest rate I_2 at time N. So interest charged per year is given by $I_{C_4} = \frac{U_1 I_{C_1}\left(N - M\right)}{T} + \frac{U_2^2 I_{C_2}}{SQ}\int_N^T Rdt$ (19)

Similarly, the retailer earns interest on sales revenue is given by $I_{E_4} = \frac{SI_e \alpha M^2}{2T}$ (20)

The total profit in this case is $TP_4 = \frac{1}{T}\left\{SR - \left(OC + HC + I_{C_4} - I_{E_4}\right)\right\}$

5. NUMERICAL VALIDATION

In this section, we take the values of parameters to validate the proposed model/

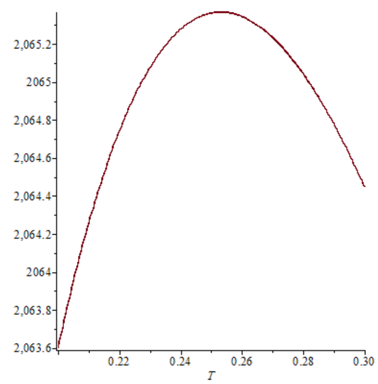
$\alpha = 70, \beta = 0.11, C = \$25$ per order, $S = \$35$ per order, $\eta = 1.2, h = \$4$ per unit time,

$A = \$10$ Per order, $I_e = \$0.025$ per time, $I_{C_1} = \$0.030$ per time, $I_{C_2} = \$0.14$ per time,

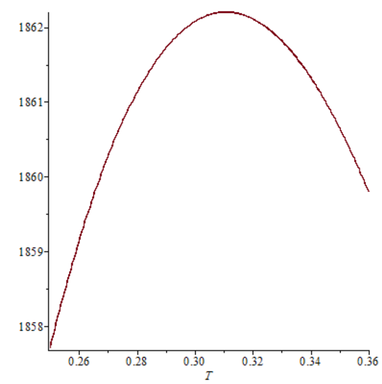
$M = 0.10$ per unit time, $N = 0.12$ per unit time

With these inventory parameters graphical representation of the profit function is validated in Maple 18 as shown below:

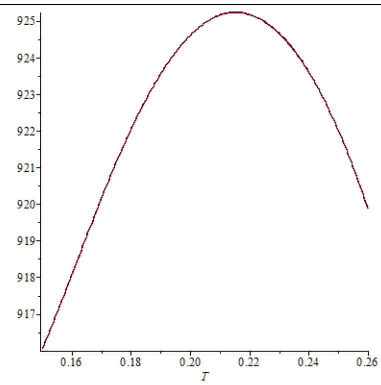
Table 2 Concavity of the objective function



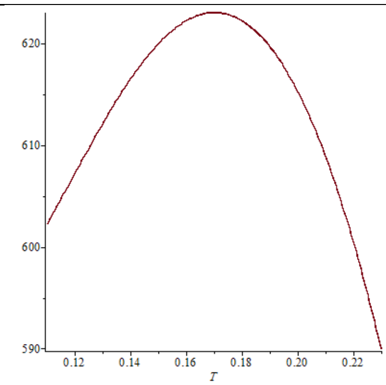
Profit function in $T < M$



Profit function in $M < T \leq W_1$



Profit function in $W_1 < T < W_2$



Profit function in $W_2 < T$

Table 3The optimal solution for different scenario

α	100	100	100	90	51	100	70	70
β	0.12	0.12	0.12	0.12	0.6	0.12	0.11	0.11
C	5	5	5	5	11.5	25	25	25
S	25	25	25	25	13	35	35	35
η	1.2	1.3	1.2	1.2	1.2	1.1	1.2	1.2
h	4	3	3	2	0.01	4	4	4
A	10	8	10	15	0.03	10	10	10
I_e	0.03	0.04	0.02	0.05	0.060	0.03	0.025	0.025
I_{C_1}	0.04	0.08	0.04	0.10	0.0991	0.04	0.030	0.027
I_{C_2}	0.14	0.16	0.2	0.20	0.22	0.12	0.14	0.15
M	0.26	0.28	0.15	0.16	0.02	0.10	0.12	0.10
N	0.28	0.30	0.17	0.18	0.06	0.22	0.127	0.12
W_1	1.3060	1.4090	0.7514	0.8040	0.0227	0.1410	0.1683	0.1403
W_2	1.4050	1.5080	0.8511	0.9032	0.0679	0.3085	0.1781	0.1682
TP_1	2080	2040	2020	1848	115.80	860	640	640.0000
T_1	0.2549	0.2515	0.3553	0.4110	0.3865	0.2036	0.2487	0.2487

TP_2	2076	2024	2036	1851	120	884	670	626.0000
T_2	0.2712	0.3042	0.2399	0.3117	0.0552	0.1388	0.1575	0.1523
TP_3	1857	1833	1981.00	1784	161.50	1011	668.8	604.9000
T_3	0.7624	0.6874	0.3731	0.3720	0.0628	0.2155	0.2554	0.1235
TP_4	1461	1266	1797	1691	0.0470	877.80	676	709.2000
T_4	0.5637	0.5988	0.3142	0.3063	77.52	0.1574	0.1883	0.1702

6. SENSITIVITY ANALYSIS

In this section, the study of changes in optimal solution by varying one parameter and keeping others as it is, variation in total profit and cycle time is exposed.

Table 4 Sensitivity Analysis

Parameter	Change in Parameter	TP_1	TP_2	TP_3	TP_4	W_1	W_2	Cycle time in maximum profit
β	0.088	500.00	648.00	599.40	**671.50**	0.14	0.17	0.1702
	0.099	630.00	693.00	640.30	**688.00**	0.14	0.17	0.1519
	0.11	640.00	626.00	649.30	**650.20**	0.14	0.17	0.1712
	0.121	640.00	524.00	660.00	**691.50**	0.14	0.17	0.1696
C	20	**1000.00**	**1088.00**	1008.00	1045.00	0.18	0.21	0.1633
	22.5	830.00	**856.00**	759.10	729.80	0.16	0.19	0.1574
	25	640.00	626.00	649.30	**650.20**	0.14	0.17	0.1712
S	31.5	460.00	**589.00**	471.60	504.30	0.1262	0.1514	0.1506
	35	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
	42	1230.00	**1271.00**	1087.00	1057.00	0.1683	0.2018	0.1562
η	1.08	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
	1.2	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
	1.32	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
	1.44	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
h	4	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
	4.4	660.00	657.00	509.40	**799.80**	0.1403	0.1682	0.1703
A	8	630.00	633.00	669.80	**698.40**	0.1403	0.1682	0.1664
	9	720.00	**800.00**	590.70	699.90	0.1403	0.1682	0.1477
	10	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
I_e	0.02	630.00	672.00	659.20	7**02.20**	0.1402	0.1681	0.1683

	0.025	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
	0.03	640.00	692.00	660.10	**694.70**	0.1403	0.1682	0.1705
I_{C_1}	0.027	640.00	626.00	580.20	**659.90**	0.1403	0.1682	0.1712
	0.030	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
I_{C_2}	0.14	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
	0.154	640.00	626.00	649.30	**700.20**	0.1403	0.1682	0.1698
	0.168	640.00	626.00	649.30	**799.30**	0.1403	0.1682	0.1686
M	0.09	640.00	509.00	581.80	**745.40**	0.1263	0.1682	0.1641
	0.10	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712
	0.11	640.00	**749.00**	659.00	670.70	0.1543	0.1682	0.1549
	0.12	640.00	**670.00**	668.80	549.50	0.1683	0.1683	0.1854
N	0.108	640.00	626.00	649.30	**657.60**	0.1402	0.1514	0.1662
	0.12	640.00	626.00	649.30	**650.20**	0.1403	0.1682	0.1712

NB: **Bold** figures represent optimum profit.

From sensitivity table 4, we can conclude that the higher value of selling price S causes higher value of profit and lower value of cycle time T, so the retailer will order more quantity to gain more profit. On the hand, higher value purchase cost C causes lower value of profit. If the ordering cost A increases, the cycle time T and profit both will increase. The higher value of holding cost h increase the total profit and reduce the cycle time T, so the retailer should order a smaller amount in quantity. If the value of parameter interest earned rate I_e increases, the profit and cycle time T decreases, so the retailer will order more frequently and earns more interest. The interest charged I_{C_1} does not impact on the value of profit and cycle time during first credit period, so the interest charged does not influence the order quantity. But as the interest charged I_{C_2} increases, the profit will increase and decrease the cycle time T during the second credit period. If the value of credit period increases, the profit decreases and cycle time increases. The inventory parameter η has marginal effect on total profit. If the value of inventory parameter β , mark-up for stop display increases, the profit will increase and cycle time will decrease.

7. CONCLUSION

In this article, an attempt is made to develop an inventory model for retailer offering a trade credit to reflect more realistic situation in which supplier gives credit period to retailer and retailer has to pay amount during first credit period or second credit period or after it without interest or with interest on the unpaid balance. Interest will be charged according to predefined terms and conditions. Here, the total profit is moderately sensible with respect to selling price, holding cost interest earned and mark-up for stop display. The inventory parameters purchase cost, ordering cost and credit period have reversible effect on total profit. Interest charged have diverse effect on different allowable credit periods. Price elasticity have marginal effect on the profit.

Acknowledgement: The authors thank DST-FIST file # MSI-097 for the technical support to the department.

RECEIVED: APRIL, 2020.
REVISED: MAY, 2020.

REFERENCES

[1] AGGARWAL, S. P., and JAGGI, C. K. (1995): Ordering policies of deteriorating items under permissible delay in payments. **Journal of the Operational Research Society**, *46*, 658-662.

[2] CHAND, S., and WARD, J. (1987): A note on "Economic order quantity under conditions of permissible delay in payments". **Journal of the Operational Research Society**, *38*, 83-84.

[3] CHANG, C. T., OUYANG, L. Y., TENG, J. T., and CHENG, M. C. (2010): Optimal ordering policies for deteriorating items using a discounted cash-flow analysis when a trade credit is linked to order quantity. **Computers and Industrial Engineering**, *59*, 770-777.

[4] CHANG, H. J., HUNG, C. H., and DYE, C. Y. (2001): An inventory model for deteriorating items with linear trend demand under the condition of permissible delay in payments. **Production Planning and Control**, *12*, 274-282.

[5] CHUNG, K. J. (2000): The inventory replenishment policy for deteriorating items under permissible delay in payments. **Opsearch**, *37*, 267-281.

[6] CHUNG, K. J., CÁRDENAS-BARRÓN, L. E., and TING, P. S. (2014): An inventory model with non-instantaneous receipt and exponentially deteriorating items for an integrated three layer supply chain system under two levels of trade credit. **International Journal of Production Economics**, *155*, 310-317.

[7] CHUNG, K. J., LIAO, J. J., TING, P. S., LIN, S. D., and SRIVASTAVA, H. M. (2018): A unified presentation of inventory models under quantity discounts, trade credits and cash discounts in the supply chain management. **Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales. Serie A. Matemáticas,** *112*, 509-538.

[8] CHUNG, K. J., LIN, S. D., and SRIVASTAVA, H. M. (2013): The inventory models under conditional trade credit in a supply chain system. **Applied Mathematical Modelling**, *37*, 10036-10052.

[9] CHUNG, K. J., LIN, S. D., and SRIVASTAVA, H. M. (2014): The inventory models for deteriorating items in the discounted cash-flows approach under conditional trade credit and cash discount in a supply chain system. **Applied Mathematics and Information Sciences**, *8*, 2103.

[10] GOYAL, S. K. (1985): On "Economic Order Quantity under conditions of permissible delay in payments" by Goyal: Reply. **Journal of the Operational Research Society**, *36*, 1069-1070.

[11] GOYAL, S. K., TENG, J. T., and CHANG, C. T. (2007): Optimal ordering policies when the supplier provides a progressive interest scheme. **European Journal of Operational Research**, *179*, 404-413.

[12] HUANG, Y. F. (2003): Optimal retailer's ordering policies in the EOQ model under trade credit financing. **Journal of the Operational Research Society**, *54*, 1011-1015.

[13] JAGGI, C. K., CÁRDENAS-BARRÓN, L. E., TIWARI, S., and SHAFI, A. (2017): Two-warehouse inventory model for deteriorating items with imperfect quality under the conditions of permissible delay in payments. **Scientia Iranica. Transaction E, Industrial Engineering**, *24*, 390.

[14] JAMAL, A. M. M., SARKER, B. R., and WANG, S. (1997): An ordering policy for deteriorating items with allowable shortage and permissible delay in payment. **Journal of the Operational Research Society,** *48*, 826-833.

[15] LIAO, J. J. (2008): An inventory control system under deferrable delivery conditions. **Mathematical and Computer Modelling,** *47*, 247-258.

[16] LIAO, J. J., HUANG, K. N., CHUNG, K. J., LIN, S. D., TING, P. S., and SRIVASTAVA, H. M. (2018): Mathematical analytic techniques for determining the optimal ordering strategy for the retailer under the permitted trade-credit policy of two levels in a supply chain system. **Filomat**, *32*, 4195-4207.

[17] SHAH, N. H. (1993): A lot-size model for exponentially decaying inventory when delay in payments is permissible. **Cahiers du Centre D'études ee Recherche Opérationnelle**, *35*, 115-123.

[18] SHAH, N. H., and CÁRDENAS-BARRÓN, L. E. (2015): Retailer's decision for ordering and credit policies for deteriorating items when a supplier offers order-linked credit period or cash discount. **Applied Mathematics and Computation**, *259*, 569-578.

[19] SONI, H., and SHAH, N. H. (2008): Optimal ordering policy for stock-dependent demand under progressive payment scheme. **European Journal of Operational Research**, *184*, 91-100.

[20] TENG, J. T., CHANG, C. T., and GOYAL, S. K. (2005): Optimal pricing and ordering policy under permissible delay in payments. **International Journal of Production Economics**, *97*, 121-129.