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Research Article

Dynamic Pricing and Replenishment Policies of Fresh Foods under Consumer's Choice

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Abstract: The study presents the dynamic pricing based on the consumer demand characteristics for fresh foods' retailers. Demand is classified by consumers' sensitivity to price and freshness of fresh products. Fresh product is classified by its length of shelf life. The model is based on the periodic inspection inventory model and considers consumers' choice behavior in mixed model of First in First Out (FIFO) and Last in First Out (LIFO). We formulate the demand function that is related to retail price and instantaneous inventory level. The retail price and the maximum instantaneous inventory at the beginning of unit period are decision variables. Next we analyze five different kinds of demand behaviors and explore different sensitivities to price and freshness in different behaviors when other parameters that influence demand are the same. Finally, we conclude that pricing should vary from different demand behaviors.

Keywords: Dynamic pricing, demand type, freshness, inventory level

INTRODUCTION

In modern times people's living standard has improved greatly and demands for fresh foods such as meat, eggs and milk are growing instantly in both quantity and quality. Currently researches on fresh foods mainly focus on sales, microorganism, food technology and other relevant fields and some on dynamic pricing are generally based on shelf life, but relatively less on considering the consumer demand characteristics. Fresh foods have fixed shelf life and the unsold products that have passed the expiration date need to be disposed by discarding or recycling in low price. To deal with these problems, attentions have been focused on ordering policy, pricing policy and consumer's demand characteristics.

The ordering policy for fresh foods is usually based on deteriorating inventory model. Life time of fresh foods is a key factor in the model. Demand is often assumed to be dependent on inventory level (Pando *et al*., 2013) and the differential equation with demand rate is well developed to express inventory level.

For pricing policy, there are several measures introduced in literatures. For example, a pricing model integrates three models, concluding cost-plus, competitor-referenced and demand-driven models (Sung and Lee, 2000). Besides, dynamic pricing is an effective tool for perishable products to better match demand with supply in recent research (Wang and Li, 2012).

Nowadays, because of insufficient understanding of main commodities sales market and failing to seize the consumers' attention, majority of merchants cannot make profits and result in some products with more waste, lower sales and higher cost. It is imperative to study on consumer's demand behaviors. In general, consumers base their purchase decisions on quality or price of products (Jia and Hu, 2011). For fresh foods, the characteristics of consumers are reflected by both the price sensitivity and the freshness sensitivity.

This study mainly focuses on the integration of ordering policy, pricing policy and consumers' demand characteristics. However, a number of studies mainly considered two factors. On one hand, some papers studied the comprehensive issue of pricing and ordering for fresh food in supply chain (Tajbakhsh *et al*., 2011). On the other hand, several pricing models have been proposed in the literature, depending on the characteristics of consumer demand (Akçay *et al*., 2010).

MATERIALS AND METHODS

Assumptions:

- The supply chain contains one perishable product and one retailer.
- The period length is assumed a unit.
- The retailer checks the inventory level and places order at the end of each period.

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- The life time of the perishable product is set m-fold of a unit period, i.e., the life time of the freshest product is m.
- Demand is known and constant. It decreases as the value of P becomes larger and increases as the value of i(t) becomes larger. The demand rate is determined as:

$$D(i(t), p) = \frac{i(t)^{\beta}}{P^{\gamma}}, 0 < \beta < 1, \gamma > 1$$

α is the scale parameter, β denotes the shape parameter which quantifies the effect of instantaneous inventory level to demand rate, γ represents the index of price elasticity.

- The system contains two consumers' choice behaviors model: LIFO and FIFO.
- There is no order lead-time. The life time of fresh products is m when the ordered goods arrive and m-1 after one period and so on.
- There is certain salvage value for unsold products.

Parameters: The subscript t denotes the time in one cycle; the superscript r denotes the period:

S^r	:	Maximum instantaneous inventory at the beginning of period r (decision variable)
P^r	:	Unit retail price of fresh products in period r (decision variable)
Q^r	:	Order quantity in period r
$i^r(t)$	:	Inventory level at time t in period r
I_b^r	:	The inventory level of fresh products before outdating at the end of period r
I_a^r	:	The inventory level of fresh products after outdating at the end of period r
C_d	:	Unit purchasing price of fresh products
C_o	:	Unit procurement cost of fresh products
C_h	:	Unit inventory carrying cost of fresh products
C_w	:	Salvage value for per unsold product
W^r	:	Quantity of outdated products in period r
M^r	:	Total sales volume for products in period r
M_j^r	:	Sales volume of products at life time i in period r
K_j^r	:	Probability of sales of products at life time i in period r

Analysis in consumers' choice model: In real sales, consumers' choice behaviors include three models: complete FIFO model, complete LIFO model and mixed FIFO with LIFO model. In LIFO, customers tend to select the last-in fresh goods from the store shelf (fresh foods have the longest life time). In FIFO, customers tend to select the first-in item from the store shelf (fresh foods have the shortest life time). For the first two models being less frequent in practice, this study merely study the mixed LIFO with FIFO model.

All fresh foods with different life time in each period are sold with a certain probability under consumers' choice behavior which mixed FIFO with LIFO, in which products with life time of 0 are outdated. We can describe the inventory level of fresh foods in single batch as follows: the inventory is the order size Q^r when orders arrive, sales volume is M^r_m in first period, M_{m-1}^{r+1} in second period and so on, each period has sales volume till unsold products are outdated from then on. At the beginning, there are products with life time of m, m-1, m-2, …, 1. Therefore, the total sales in period r are made up by the fresh foods with different life time, that is $M^r = \sum_{i=1}^{m} M_j^r$.

Under the consumers' mixed choice behavior, the differential equation expressing the time-dependent inventory level $i^r(t)$ is given by:

$$\frac{di^r(t)}{dt} = -\frac{\alpha\left[i^r(t)\right]^{\beta}}{\left[P^r\right]^{\gamma}}, 0 < t < 1 \tag{1}$$

From formula (1) and the initial condition $i^r(t) = S^r$ at t = 0, $i^r(t)$ becomes:

$$i^r(t) = \left[S^{r(1-\beta)} - \frac{\alpha(1-\beta)t}{\left[P^r\right]^{\gamma}}\right]^{\frac{1}{1-\beta}}, 0 < t < 1 \tag{2}$$

Therefore, the inventory level I^r_b is:

$$i_b^r = i^r(1) = \left[S^{r(1-\beta)} - \frac{\alpha(1-\beta)}{\left[P^r\right]^{\gamma}}\right]^{\frac{1}{1-\beta}} \tag{3}$$

In addition, the holding amount of inventory during the period r is:

$$H^r = \int_0^1 i^r(t)dt = \frac{\left[P^r\right]^{\gamma}}{\alpha(2-\beta)}\left\{\left(S^r\right)^{2-\beta} - I_b^{r(2-\beta)}\right\} \tag{4}$$

The amount of outdated goods at the end of period r is:

$$W^r = S^{r-(m-1)} - I_b^{r-(m-1)} - \left(\sum_{j=1}^{m} M_j^{r-(m-1)}\right) \quad (5)$$

Taking two kinds of inventory level into consideration, $S0^r$ is the level which makes $i^r(1) = 0$, $S1^r$ is the maximum inventory level which makes $W^r = 0$, so we can have the following identity from the definition of $S0^r$:

$$i(1) = \left[S^{r(1-\beta)} - \frac{\alpha(1-\beta)}{\left[P^r\right]^{\gamma}}\right]^{\frac{1}{1-\beta}} = 0$$

Then we have:

$$S0^r = \left[\frac{\alpha(1-\beta)t}{\left[P^r\right]^{\gamma}}\right]^{\frac{1}{1-\beta}} \quad (6)$$

From the definition of $S1^r$ we know:

$$S1^r = M_1^r + \left(M_1^{r+1} + M_2^r\right) + \cdots + \left(M_1^{r+(m-1)} + M_2^{r+(m-2)} + \cdots + M_m^r\right)$$

The life time of fresh foods is generally short and the customer demand fluctuation is small in short time, so $S1^r$ can be expressed according the demand in current period as follows:

$$\begin{aligned} S1^r &= M_1^r + \left(M_1^r + M_2^r\right) + \cdots + \left(M_1^r + M_2^r + \cdots M_m^r\right) \\ &= \left(mM_1^r\right) + (m-1)M_2^r + \cdots + M_m^r \\ &= \left\{\left(mk_1^r\right) + (m-1)k_2^r + \cdots + k_m^r\right\} M^r \end{aligned}$$

Then we substitute $M^r = \int_0^1 \frac{\alpha\left[i^r(t)\right]^{\beta}}{\left[P^r\right]^{\gamma}} dt$ and Eq. (2) into (1):

$$S1^r = \left\{\left(mk_1^r\right) + (m-1)k_2^r + \cdots + k_m^r\right\} \frac{1}{m} \left\{\frac{1}{\left(P^r\right)^{\gamma}} * \frac{\alpha(1-\beta)}{1-\left[(m-1)/m\right]^{1-\beta}}\right\}^{\frac{1}{1-\beta}} \quad (7)$$

Case of products in different life time having the same sale price: In this case, the value of K_j^r mainly depends on two factors: The first one is consumers' purchase habit, concretely speaking; customers select items from the displayed goods sorted by the retailer. The second one is consumers' concern for freshness, which means products can be run out of before expire date by consumers, so there is no need to choose these of longest life time.

- In the interval of $S^r > S1^r$, the number of outdated items becomes nonzero and the profit of retailer in single period can be shown as:

$$\begin{aligned} MAX\pi^r\left(S^r, P^r\right) = &\left\{P^r\left(S^r - I_b^r\right) - C_d\left(S^r - I_b^r\right) \right. \\ &\left. - C_h H^r - C_0\right\} - \left\{\left(C_d - C_w\right)W^r\right\} \end{aligned} \quad (8)$$

$$S^r > \left\{\left(mk_1^r\right) + (m-1)k_2^r + \cdots + k_m^r\right\} * \frac{1}{m}\left\{\frac{1}{\left(P^r\right)^{\gamma}} * \frac{\alpha(1-\beta)}{1-\left[(m-1)/m\right]^{1-\beta}}\right\}^{\frac{1}{1-\beta}} \quad (9)$$

$$i_b^r = i^r(1) = \left[S^{r(1-\beta)} - \frac{\alpha(1-\beta)}{\left[p^r\right]^{\gamma}}\right]^{\frac{1}{1-\beta}}$$

$$H^r = \int_0^1 i^r(t)dt = \frac{\left[P^r\right]^{\gamma}}{\alpha(2-\beta)}\left\{\left(S^r\right)^{2-\beta} - I_b^{r(2-\beta)}\right\}$$

$$W^r = S^{r-(m-1)} - I_b^{r-(m-1)} - \left(\sum_{j=1}^{m} M_j^{r-(m-1)}\right)$$

- In the interval of $S0^r \le S^r \le S1^r$, there is no outdated item, so $I_b^r = I_a^r$, the profit of retailer in single period can be shown as:

$$MAX\pi^r\left(S^r, P^r\right) = \left\{P^r\left(S^r - I_b^r\right) - C_d\left(S^r - I_b^r\right) - C_h H^r - C_0\right\} \quad (10)$$

$$S^r \le \left\{\left(mk_1^r\right) + (m-1)k_2^r + \cdots + k_m^r\right\} * \frac{1}{m}\left\{\frac{1}{\left(P^r\right)^{\gamma}} * \frac{\alpha(1-\beta)}{1-\left[(m-1)/m\right]^{1-\beta}}\right\}^{\frac{1}{1-\beta}} \quad (11)$$

$$S^r \ge \left[\frac{\alpha(1-\beta)t}{\left[P^r\right]^{\gamma}}\right]^{\frac{1}{1-\beta}} \quad (12)$$

$$i_b^r = i^r(1) = \left[S^{r(1-\beta)} - \frac{\alpha(1-\beta)}{\left[p^r\right]^{\gamma}}\right]^{\frac{1}{1-\beta}}$$

$$H^r = \int_0^1 i^r(t)dt = \frac{\left[P^r\right]^\gamma}{\alpha(2-\beta)}\left\{\left(S^r\right)^{2-\beta} - I_b^{r(2-\beta)}\right\}$$

Case of products in different life time having different sale prices: In this case, the fresh products' price and sales volume vary from different life time. Let K_j^r be the probability of sales for products at life time i in period r and $\sum K_j^r = 1$. The value of K_j^r is related to consumers' sensitivity to the price and freshness of fresh products. Consumers' demands differ in sensitivity to the price and freshness. So we introduce the utility function, consumers' utility is made up of two parts: prediction and random part. For the products of age m and price a, the factor of consumers' sensitivity to price $\theta > 0$ and the factor of consumers' sensitivity to freshness $\varphi > 0$ and consumers' utility decreases as products' price increasing or remaining life time decreasing. Let P_j be the price of products whose remaining life time is j. so average utility function in period r is $V_j^r = U_m - \theta P_j^r - \varphi(m-j) + \varepsilon_j$, in which j = 1, 2,…, m and it is a random variable that follows *Gumbel* distribution. Based on the above assumptions, we can establish probability formula of *Logit* model and the probability of sales for products at life time i in period r is:

$$k_j^r = \left[\frac{e^{U_m - \theta P_j^r - \varphi(m-j)}}{\sum_{j=1}^m e^{U_m - \theta P_j^r - \varphi(m-j)}}\right], j = 1, 2, \cdots, m \tag{13}$$

- In the interval of $S^r > S1^r$, the number of outdated items becomes nonzero and the profit of retailer in single period can be shown as:

$$\begin{aligned} MAX\pi^r\left(S^r, P^r\right) = &\left\{P^r\left(S^r - I_b^r\right) - C_d\left(S^r - I_b^r\right)\right. \\ &\left. - C_h H^r - C_0\right\} - \left\{\left(C_d - C_w\right)W^r\right\} \end{aligned} \tag{14}$$

$$\begin{gathered} S^r > \left\{\left(mk_1^r\right) + (m-1)k_2^r + \cdots + k_m^r\right\} \\ * \frac{1}{m}\left\{\frac{1}{\left(P^r\right)^\gamma} * \frac{\alpha(1-\beta)}{1 - \left[(m-1)/m\right]^{1-\beta}}\right\}^{\frac{1}{1-\beta}} \end{gathered} \tag{15}$$

$$i_b^r = i^r(1) = \left[S^{r(1-\beta)} - \frac{\alpha(1-\beta)}{\left[p^r\right]^\gamma}\right]^{\frac{1}{1-\beta}}$$

$$P^r = \sum_{j=1}^m k_j^r P_j^k \tag{16}$$

$$H^r = \int_0^1 i^r(t)dt = \frac{\left[P^r\right]^\gamma}{\alpha(2-\beta)}\left\{\left(S^r\right)^{2-\beta} - I_b^{r(2-\beta)}\right\}$$

$$k_j^r = \left[\frac{e^{U_m - \theta P_j^r - \varphi(m-j)}}{\sum_{j=1}^m e^{U_m - \theta P_j^r - \varphi(m-j)}}\right], j = 1, 2, \cdots, m$$

$$W^r = S^{r-(m-1)} - I_b^{r-(m-1)} - \left(\sum_{j=1}^m M_j^{r-(m-1)}\right)$$

- In this interval of $S0^r \le S^r \le S1^r$, there is no outdated item, the profit of retailer in single period can be shown as:

$$MAX\pi^r\left(S^r, P^r\right) = \left\{P^r\left(S^r - I_b^r\right) - C_d\left(S^r - I_b^r\right) - C_h H^r - C_0\right\} \tag{17}$$

$$\begin{gathered} S^r \le \left\{\left(mk_1^r\right) + (m-1)k_2^r + \cdots + k_m^r\right\} \\ * \frac{1}{m}\left\{\frac{1}{\left(P^r\right)^\gamma} * \frac{\alpha(1-\beta)}{1 - \left[(m-1)/m\right]^{1-\beta}}\right\}^{\frac{1}{1-\beta}} \end{gathered} \tag{18}$$

$$S^r \ge \left[\frac{\alpha(1-\beta)t}{\left[P^r\right]^\gamma}\right]^{\frac{1}{1-\beta}} \tag{19}$$

$$P^r = \sum_{j=1}^m k_j^r P_j^k$$

$$k_j^r = \left[\frac{e^{U_m - \theta P_j^r - \varphi(m-j)}}{\sum_{j=1}^m e^{U_m - \theta P_j^r - \varphi(m-j)}}\right], j = 1, 2, \cdots, m$$

$$i_b^r = i^r(1) = \left[S^{r(1-\beta)} - \frac{\alpha(1-\beta)}{\left[p^r\right]^\gamma}\right]^{\frac{1}{1-\beta}}$$

$$H^r = \int_0^1 i^r(t)dt = \frac{\left[P^r\right]^\gamma}{\alpha(2-\beta)}\left\{\left(S^r\right)^{2-\beta} - I_b^{r(2-\beta)}\right\}$$

Eq. (9), (11), (12), (15), (18) and (19) constrain the relations among S^r, $S1^r$ and $S0^r$, their relationships determine the quantity of outdating products. Eq. (16) is the expression of average price that is computed through the demand rate of fresh foods in different life time.

RESULTS AND DISCUSSION

The model is programmed and solved in MATLAB environment. The value of parameters is based on historical sales data of local fresh food industry.

Retailers' order quantity in period r is Q^r and we suppose the products' life time are 3, namely $m = 3$.

Thus the inventory of products in the beginning of period is Q^r when $m = 3$, $Q^{r-1} - M_3^{r-1}$ when $m = 2$ and $Q^{r-2} - M_3^{r-2} - M_2^{r-1}$ when $m = 1$.

Impact of parameters on price, profit and maximum inventory: We choose the first model in 4.2 to discuss for remaining products can exist in this model and variation range of price, profit and inventory level is relatively wide, the effect of parameters is more obvious. In order to study the effect of parameters on price, profit and maximum inventory, we mainly do analysis of sensitivity on four parameters. And for every parameter' analysis of sensitivity, this parameter vary from lower bound to upper bound with an increment, while other three parameters are fixed average value in their interval. Other basic parameters are:

$$\alpha = 500, c_0 = 10, c_h = 0.5, c_d = 10, c_w = 5, m = 3,$$
$$5 \le p_j^r \le 35$$

- Parameter analysis of sensitivity of demand to price ($1.40<\gamma<1.60$, $\beta = 0.5$, $\varphi = 3$, $\theta = 0.15$)

γ is the sensitivity of demand to price, profit and maximum inventory level decreases as γ becomes larger (Fig. 1). From Fig. 2, the range of profit is 486.439, it indicates that the sensitivity of demand to price is high. In Fig. 1, the price of products in remaining life time 3(the freshest) is the highest, but decreases with the increasing of γ, the smaller value of γ shows that sensitivity of demand to price is smaller, therefore, when γ is smallest, the demand is high even though P_2 is very high.

- Parameter analysis of sensitivity of demand to inventory ($0.40<\beta< 0.60$, $\gamma = 1.5$, $\varphi = 3$, $\theta = 0.15$ β is the sensitivity of demand to price, profit and maximum inventory level increases as β becomes larger and range of profit is 579.649, it also indicates that the sensitivity of demand to price is high. From the analysis of Fig. 3, the effect on products is slightly when the value of β change, but from Fig. 4 we know when $\beta = 0.55$, the inventory in the beginning of period and the profit are maximum. The profit gap results from the different instant inventory in the beginning of period, higher instantaneous inventory means higher demand rate and higher profit.
- Parameter analysis of sensitivity of consumer utility to price ($1 < \theta < 6$, $\beta = 0.5$, $\gamma = 1.5$, $\varphi = 0.15$) θ reflects the sensitivity of consumer utility to

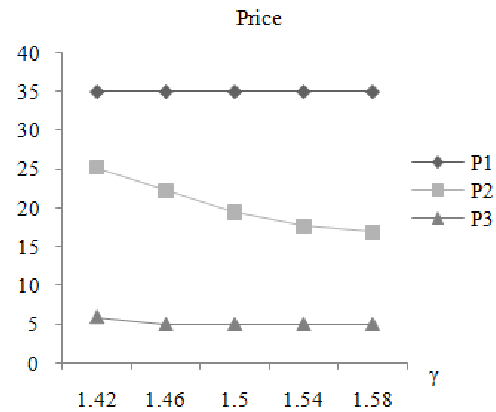

Fig. 1: Price in different value of γ

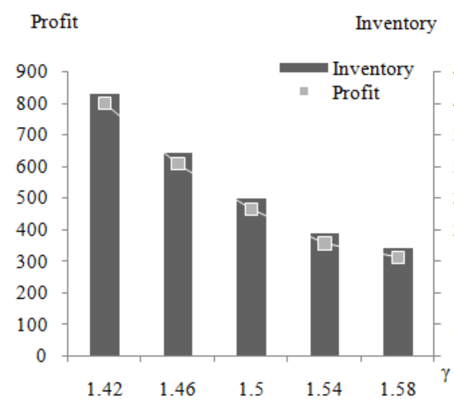

Fig. 2: Inventory and profit in different value of γ

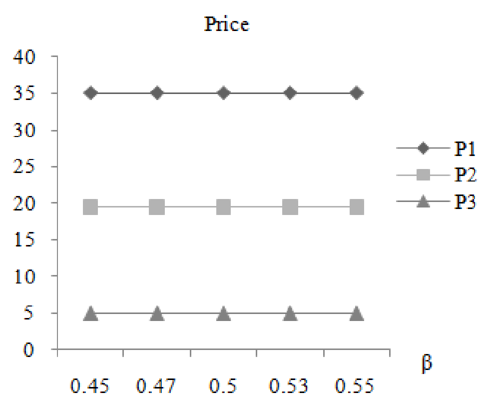

Fig. 3: Price in different value of β

price, it influences the profit by influencing the choices of consumers among different products, in which profit and maximum inventory level decreases as θ becomes larger. From Fig. 5, we know that the higher the pricing on all kinds of products, the larger the profit of unit product. The smaller the θ, the less the sensitivity of consumer utility to price, although the price is high because of the high freshness, it doesn't lead consumers to

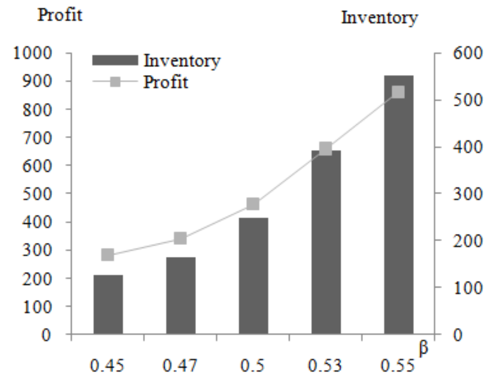

Fig. 4: Inventory and profit in different value of β

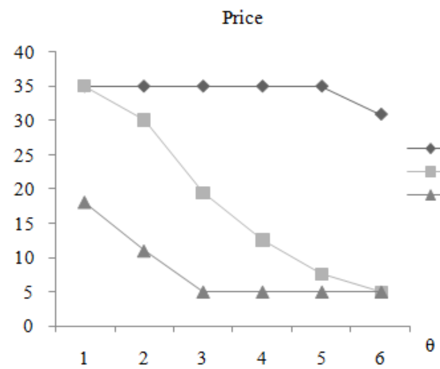

Fig. 5: Price in different value of θ

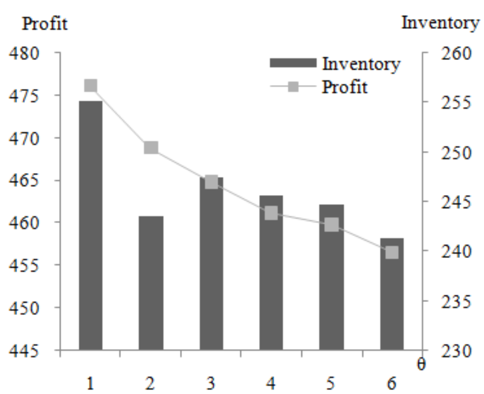

Fig. 6: Inventory and profit in different value of θ

choose the low price, low freshness, low profit products and vice versa. From Fig. 6, greater value of θ leads to lower price and smaller profit, it because consumers tend to choose the lower price, lower freshness and lower profit products.

- Parameter analysis of sensitivity of consumer utility to freshness ($0.01 < \varphi < 0.17$, $\beta = 0.5$, $\gamma = 1.5$, $\theta = 3$) φ reflects the sensitivity of consumer utility to freshness, it influences profit by influencing the choices of consumers among different products, in which profit and maximum inventory decreases as

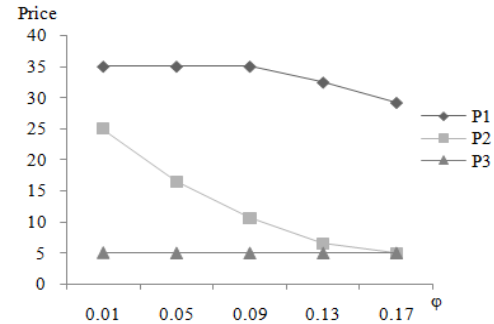

Fig. 7: Price in different value of φ

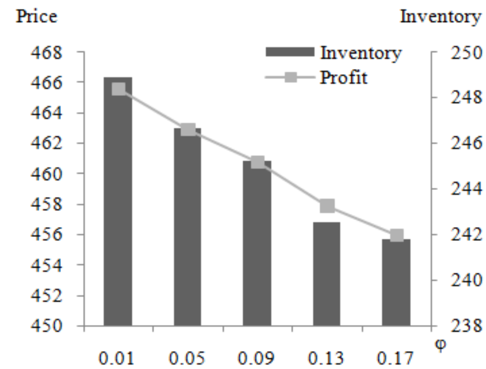

Fig. 8: Inventory and profit in different value of φ

φ becomes larger. From Fig. 7 and 8, we know that the smaller the value of φ, the higher the pricing on all kinds of products and the larger the profit of unit product. Because consumers will choose the lower price, lower freshness, lower profit products when sensitivity of consumers' utility to freshness is small and the difference between P_2 and P_3 is large. While the value of φ in turn becomes larger and the price becomes lower, consumers tend to buy higher price and fresher products though P_2 and P_3 are low. Because the proportion that consumer choose the products brought by consumers at life time 3 is maximum, the pricing formula that influences demand can be expressed $p^r = \sum_{j=1}^{m} k_j^r p_j^k$, we price P_3 low to stimulate demand.

Analysis in different demand behavior: We mainly divide the demand behaviors into five types. First, the sensitivity of the consumer to price and freshness has a negative correlation. Region is not sensitive to price and freshness and consumers accept high price to buy the stale products, region is sensitive to price and freshness and consumers expect to buy the freshest products at very low price. These two types of demand behaviors which can't be satisfied are not taken into consideration. Five types can be found from Fig. 9.

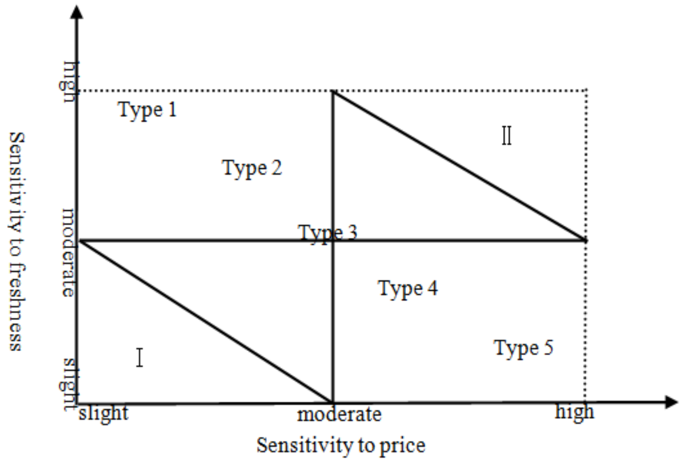

Fig. 9: Different types of demand behaviors

Table 1: Optimal price, instantaneous inventory and profit at the same price in different demand

	Life time			w = 0			w ≠ 0		
Type	3(%)	2(%)	1(%)	P	S	π	P	S	Π
1	99	0.5	0.5	20.50	27.70	203.42	27.59	241.84	456.10
2	97	2.0	1.0	20.45	28.45	206.81	27.46	243.07	458.22
3	97	1.5	1.5	20.45	28.60	207.48	27.44	243.32	458.65
4	93	5.0	2.0	20.39	29.95	213.46	27.20	242.93	459.96
5	90	7.0	3.0	20.36	30.85	217.37	27.06	247.09	465.14

Table 2: Optimal price, instantaneous inventory and profit at the different price in different demand

	w = 0					w ≠ 0				
Type	P1	P2	P3	S	π	P1	P2	P3	S	π
1	20.56	0	0	27.30	201.68	27.67	19.89	19.89	241.15	454.56
2	20.69	0	0	27.39	202.40	27.84	5.00	5.00	241.18	455.00
3	22.09	0	0	27.52	207.95	29.08	5.00	5.00	241.50	455.80
4	35.00	13.06	0	53.62	292.64	35.00	20.27	5.00	247.54	464.42
5	35.00	17.38	12.00	56.98	314.21	35.00	31.46	13.23	252.06	470.76

And then we explore different sensitivities to price and freshness in different demand behaviors on the condition that β and γ are the same and numerical computations are done for two cases based on the model, so it can be more convenient to make comparison for profits in different cases. The parameters are as follows: $\alpha = 500$, $\beta = 0.5$, $\gamma = 1.5$, $c_s = 10$, $c_0 = 10$, $c_h = 0.5$, $c_d = 10$, $c_w = 5$, $m = 3$, $5 \le p_j^r \le 35$. $\theta = 0.04$, $\varphi = 7$ at type 1, $\theta = 0.05$, $\varphi = 6$ at type 2, $\theta = 0.09$, $\varphi = 5$ at type 3, $\theta = 0.12$, $\varphi = 2.5$ at type 4, $\theta = 0.15$, $\varphi = 1.7$ at type 5.

- Products are sold without being classified at the same price. Optimal price, instantaneous inventory, profit in different demand behaviors are presented in Table 1.
- Products are sold with being classified and retail prices vary from different shelf life. Price, instantaneous inventory, profit in different demand behaviors are presented in Table 2.

Results indicate: First of all, for both two cases, the profit is higher if the outdating quantity is allowed to be zero (w = 0) than that if the outdating quantity isn't allowed to be zero (w ≠ 0), the reason is that the maximum inventory in the beginning of period (S) is bigger and it lead to higher demand rate when the outdated items are allowed. Secondly, demand behaviors of high sensitivity to price and low sensitivity to freshness (type 4 and type 5) are more suitable for classified sales, because these behaviors are sensitive to price, it is likely to attract more customers after differential pricing by classification. Finally, demand behaviors of high sensitivity to freshness (type 1 and type 2) are not suitable for classified sales, because these consumers prefer to choose products of high freshness and high price in classified sales, they tend to LIFO no matter the price is high or low.

Our findings integrated the general ideas of ordering policy, pricing policy and consumers' demand characteristics. One part of our model is inventory model and the inventory model under LIFO and FIFO policies had detailed explanation by Hahn *et al*. (2004), they mainly focused on the issues in the wholesale market. We took this model for reference and established the mixed LIFO with FIFO model in joint market of wholesale and retail. There are several existing research literatures studying dynamic pricing for perishable products (Akçay *et al*., 2010; Jia and Hu, 2011). These findings, however, do not subdivide consumers' choice behavior according to their sensitivity to freshness and price of fresh foods. This study provides a model to show how to price for fresh foods in different consumption areas.

CONCLUSION

In this study, we discuss dynamic pricing of fresh foods under consumer's choice. A pricing model based on consumer's demand characteristics on price and freshness is built. The retail price and the maximum instantaneous inventory at the beginning of the period are decision variables. The numerical analysis shows three important conclusions. First, price and freshness are two important factors that affect demand through sensitivity analysis and they have some certain positive or negative correlations with demand. Second, after excluding the effect of shape parameters, the numerical computations on further subdividing consumer's demand behaviors reveal that pricing should differ in demand behavior. Third, given the potential profits of disposal value, it is desirable for retailers to make the best of the salvage value of unsold products and reasonably control the quantity of outdated products to make more profits.

There are several extensions to our research. The system mainly focuses on one perishable product and one retailer; it would be interesting to establish the model with multiple perishable products and multiple retailers. The effect of shelf space resource could be an impotent factor to enrich the study.

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