Pricing Policy and Optimal Production Quantity with Demand Depends on Price

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Abstract

Consumers have a tendency to buy goods with good quality at low prices, while the price for the company is a determining factor for the resulting profit. Determining the right price is an important thing to consider, because if the price is set too high then the risk is that only a few products will be sold, but if the price is set too low it will reduce the profits. On the other hand, with the various types of items produced, there is often a shortage of stock for certain types and excess stock for other types. Therefore, to produce products with competitive prices and profit in accordance with the wishes of the company, the company must carry out production planning properly so that production operations can run effectively and efficiently. In this study, we develop a pricing policy model and the optimal combination of production quantities for multi-item products with demand is a function of prices. The aim is to determine the right pricing model based on stochastic consumer valuations and simultaneously determine the optimal combination model of the number of products that must be produced for each item in order to maximize company profits. While the model solution is done by using integer linear programming approach.

Keywords: Pricing policy, product combination, stochastic demand, integer linear programming

1. Introduction

The development of the industrial sector which is relatively rapid and continuous, increasingly encourages competition between companies in taking market share. These companies must have the same goal of gaining profit or profits as much as possible. The component of profit formation is income derived from the sale of production and services produced by the company,while cost is a sacrifice that must be spent by the company to produce or produce something goods or services. Every company is required to be able to present quality products at prices that are acceptable to consumers. Product pricing is something that needs to be considered well by companies. The determination of the cost should be appropriate and accurate,so the cost of goods will also show the real value. A selling price that is too high will make the product less competitive in the market, while a selling price that is too low will not benefit the company. Pricing must be done carefully and precisely. In addition to pricing, determining the amount of production is also an important thing that must be considered by the company. Because the amount of production is excessive or less on demand, will both have an impact on the company.

Ahn, et al (2007) mention that consumers in deciding to buy or not are influenced by prices, both current prices, previous prices or possible future prices. Setting the price too high will cause sales to decline, but if the price is too low it will reduce the profits that can be obtained by the company. According to Gayon, et al (2009), there are three strategies that can be used in determining the selling price. The first is static pricing, where the selling price is the same or fixed for one selling season, the second is environment dependent pricing, where prices change according to existing demand, and the third is dynamic pricing, where price changes depend on demand and available supply conditions.

Research on pricing policies and optimal production planning has been carried out by several researchers. Segal (2003) developed a stochastic price model by looking at consumer valuation. This distribution of valuation is used as the basis for determining the price that maximizes profits. Ahn et al (2007) developed a pricing policy model and optimal production planning, where demand is a function of price. Ahn et al's model is deterministic. Production planning is based on incoming demand and inventory in the warehouse.

Gayon et al (2009) investigated pricing strategies and carried out production planning with fluctuating demand. Meanwhile, Nurmala (2013) collaborates on pricing and production planning models from research conducted by Ahn et al (2007) and Segal (2003), The price model developed by Nurmala is deterministic and is based on a linear price-demand model and a nonlinear price-demand model. The pricing strategy used is static pricing.

Some of the studies above have similar characteristics, namely both determining optimal selling prices and production planning for single items with static pricing. In fact, there are many companies that produce more than one type of product, besides that there are also companies that produce items that have an expiration date. Variations in the number and types of items produced make the company need to determine the optimal price for each product and at the same time determine the optimal amount of production for each product so that the profits obtained by the company can be maximized.

This paper develops a policy model for determining pricing and optimizing product combinations. The price model developed is the model created by Ahn (2007), namely the optimal price model for a single item that uses static pricing pricing where the pricing is based on demand that is linear to the price. The purpose of this research is to determine the price policy for multi-item products and simultaneously determine the optimal production quantity for each item so that the company's profits can be maximized.

2. Literature Review

Price is the amount of money charged for a product or service. Price also expresses the amount of value that customers receive for the benefits of owning or using the product or service (Kotler & Armstrong 2018). Price is a basic component that directly affects the company's profit. The set price level affects the quantity of goods sold. The price of a product determines the revenue generated by the company from the sale of goods and services. In general, pricing is influenced by the operational costs incurred by the company to produce a product or service (Smith,2011; Kienzler & Kowalkowski, 2017). Pricing is a relevant resource and a vital tool for any company's financial life and one of the most crucial, challenging, and subjective decisions. Its complexity and implementation difficulties present major challenges to many organizations (Avlonitis & Indounas, 2006; Hinterhuber & Liozu, 2012, 2014; Shi et al., 2015; Tian et al., 2005; Wagner & Beinke, 2006)

Price has a strong impact on sales volume and market share. Pricing is part of a business strategy related to product marketing and business objectives of a company (Liozu & Hinterhuber, 2013; Caregnato et al., 2014)). Pricing has a direct influence on demand, manifesting itself more quickly than other marketing elements (Melo et al., 2013). Pricing decisions are one of the most critical management choices because they affect profitability and offer a competitive advantage to the company. Therefore, pricing decisions and strategies play an important role in every company (Nyaga, 2017; Monroe, 2003). Pricing strategy has been considered as an effective way to achieve success for many retailers. To determine a good pricing strategy, the retailer should understand customer characteristics and behavior (Kardes et al. 2011).

Customer-based factor is not the only aspect to consider in determining the pricing strategy used. The market competition also impacts pricing as the competitors can influence the customer decision-making process. Moreover, the format of retailers can affect the inventory capacity of retailers, where the stock availability also influences the price determination process. In addition, when the issue viewed from a supply chain perspective, the competitive behavior of retailers in determining prices can affect the income of the suppliers. Therefore, it is reasonable to state that understanding retail pricing strategy requires a systematic approach. According to Fletcher (2015),

there are five important steps to take when setting prices. The first step is determining business goals, the second step is conduct market pricing analysis, the third step is analyzing the target market, the fourth step is the profile of competitors, and the fifth step is creating pricing plan and executing plan.

3. Model Development

The model proposed in this study is an optimal pricing model and optimization of the number of multi-item products using static pricing strategies in pricing.
The notations used in developing this model are as follows:

Z_t : total profit in period t
a_{it} : amount of raw material used to make product *i* in period t
b_i : amount of raw material available to make all product *i* in period t
c_i : production cost of product *i* per unit
d_{it} : demand of product *i* in period t
d_{iT}^0 : the maximum demand of product *i* in the selling season period *T*
p_{iT} : the price of product *i* in the selling season period *T*
$d_{it}(p_{iT})$: demand for product *i* at price p_T
$P(p_{iT})$: profit of product *i* at price p_{iT} in the selling season *T*
$P(p_T)$: profit at price p_T in selling season *T*
$R(p_T)$: income at price p_T in selling season *T*
p_i^* : the optimal price of product *i*
h_i : holding cost per unit of product *i*
I_{it} : inventory of product *i* at period *t*
Q_{it} : production capacity of product i at period t
S_{iT} : the price-demand sensitivity of product i in the selling season T
μ_i : average product demand i
x_{it} : number of products produced in period t
g_{it} : number of products i sold in period t
wp_{ij} : processing time of product i at work station j
wt_j : working time available at work station j
t : planned period, $t = 1,2,\ldots,12$
T : selling season period, $T = 1,2,\ldots,6$
i : 1, 2, 3
j : 1, 2, ..., 9

The stages in solving problems with the proposed model are as follows:

1) Build a basic model of demand for each product, because the price of one product does not affect the demand for the other product.

$$d_{iT}(p_{iT}) = d_{iT}^0 - s_{iT}p_{iT} \quad (1)$$

2) Calculate the total revenue obtained when selling the entire product.

$$R(p_T) = \sum_{i=1}^{n} p_{iT}d_{iT} \quad (2)$$

3) Calculate the total profit earned for all products sold is calculated.

$$P(p_T) = \sum_{i=1}^{n} (p_{iT} - c_i)\left(d_{iT}^0 - s_{iT}p_{iT}\right) \quad (3)$$

(3)

4) Calculate the optimal price for each product

$$p_i{}^* = \frac{d_i^0 + c_i s_i}{2s_i} \tag{4}$$

After the optimal price is obtained, the next step is to determine the optimal amount of production that must be made by the company to maximize profits. The mathematical model for the optimal amount of production that can maximize profits is as follows:

Objective function:

$$max\,(Z_t) = \sum_{i=1}^{3}\sum_{t=1}^{12} p_i g_{it} - \sum_{i=1}^{3}\sum_{t=1}^{12} c_i x_{it} - \sum_{i=1}^{3}\sum_{t=1}^{12} h_i I_{it} \tag{5}$$

Subject to

$$\sum_{t=1}^{12}\sum_{i=1}^{3}\sum_{j=1}^{9}(wp_{ijt} \times x_{it}) \leq wt_{jt} \tag{6}$$

$$\sum_{t=1}^{12}\sum_{i=1}^{3}(a_{it} \times x_{it}) \leq b_t \tag{7}$$

$$x_{it} \leq Q_{it} \tag{8}$$

$$x_{it} \geq 0 \tag{9}$$

$$I_{it} \geq 0 \tag{10}$$

$$g_{it} \geq 0 \tag{11}$$

Equation (1) shows the number of requests for product i at price p_T. Equation (2) to find the company's total revenue by selling all products. Equation (3) to find the company's total profit. Equation (4) to calculate the selling price of each product. Equation (5) is the objective function for maximizing profits. Equation (6) is the processing time constraint, Equation (7) is the raw material used constraint, Equation (8) is the production capacity constraint, Equations (9) to (10) are non-negative constraints.

The solution procedure used in solving the developed model is as follows:

1) Calculating the amount of decrease in demand that follows the percentage decrease in the number of consumers based on the price increase that consumers want (consumer valuation).
2) Plot the consumer valuation of each product with the demand for each valuation to obtain a demand model for each product based on the price consumers want.
3) Calculating the optimal selling price of each product (4)
4) Comparing the total profit based on the company's method and based on the proposed model
5) Determining the optimal amount of production that must be made by the company to maximize profits using integer linear programming. The objective function and the considered constraints have been formulated as shown in equations (5) to (11).

4. Data Collection

Validation of the model will be carried out, namely by applying the model to real cases at the garment industry. The data needed for validation can be seen in Table 1 to Table 7.

Table 1. Demand of item

	Demand (pcs)		
Period (t)	**Item-I**	**Item-2**	**Item-3**
1	1876	119	110
2	1870	134	83
3	1874	82	74
4	1882	68	62
5	1876	139	113
6	1872	154	86
7	1884	105	77
8	1875	79	58
9	1877	108	95
10	1885	94	61
11	1879	71	139
12	1889	83	110
Total	22,539	1,236	1,068
Average	1878	103	89

Table 2. Production capacity of item *i*

Production capacity, unit		
Item-1	**Item-2**	**Item-3**
1865	105	90

Table 3. Selling prices, production cost, and holding cost

Item	Selling price	Production cost	Holding cost
1	45000	22675.26	450
2	65000	33300.32	650
3	80000	38125.06	800

Table 4. Processing time and time availability

Production Process/ Machinery	Processing time (minute)			Processing time availability (minute)
	Item-I	**Item-2**	**Item-3**	
Cutting/Cutting Machine	0.48	0.497	0.55	31,5
Sewing/Serger Machine-I	1.235	1.235	1.251	84
Sewing/Overdeck Machine-I	1.42	1.42	1.5	52,5
Sewing/Sewing Machine-I	4.01	4.01	4.31	52,5
Sewing/Overdeck Machine-2	1.42	1.42	1.5	52,5
Sewing/Sewing Machine-2	1.28	1.28	1.3	31,5
Sewing/SergerMachine-2	1.235	1.235	1.251	84
Dryer/Screen Printing	5	5	5	31,5
Labelling	2.08	2.09	2.1	42
Total	18.16	18.177	18.762	415.8

Table 5. The need and availability of raw materials per period

Raw materials	The need of raw materials			The availability of raw materials
	Item-I	Item-2	Item-3	
Cotton 20S (kg)	0.265			500
Lacoster Cotton (kg)		0.45		50
Fleece Cotton (kg)			0.5	50
Overlock Thread (kg)	0.03	0.03	0.04	80
Sewing Thread (kg)	0.02	0.02	0.03	80
Rib CTCBSN (kg)	0.04	0.04		100
Cat Rubber (kg)	0.02		0.08	50
Cat Plastisol		0.04		10
Binder (kg)	0.015	0.017	0.025	50
Pigmen (kg)	0.026	0.028	0.037	100
Jell (pcs)			1	150
Label (pcs)	2	2	2	4500

Table 6. Customer Valuation

Customer Valuation		
Item-1	Item-2	Item-3
41625	60125	74000
42750	61750	76000
43875	63375	78000
45000	65000	80000
45125	66625	82000
47250	68250	84000

5. Results and Discussion

Problem-solving by implementing the proposed model will determine the optimal price and optimal production quantity for each item. A summary of the comparison of the total revenue and profits obtained by the company when setting a selling price in accordance with the results of the model developed with the method used by the company can be seen in Table 7.

Table 7. Comparing the total profit based on the company's method and the proposed model

Item *i*	Production cost	Selling prices		The total profit	
		The proposed model	Company's method	The proposed model	Company's method
1	22675	36300	45000		
2	33300	53250	65000	156090000	114902000
3	38125	64500	80000		

Based on the results of calculations that have been done, that the price obtained based on the model developed is smaller than the price set by the company. This is because the selling price of the model in its calculations is influenced by the maximum demand for the price. While the price set by the company is only based on the amount of profit that the company wants to get. Meanwhile, based on the proposed price model, the total profit obtained is greater than the total profit based on the price set by the company.

The next step is to determine the optimal production quantity that must be made to maximize profits using integer linear programming. Based on the objective function and constraints in equations (1) to (5), the optimal production quantity is obtained as shown in Table 8.

Table 8. The optimal production quantity

Period	Product		
	1	2	3
1	1865	103	89
2	1847	102	88
3	1857	102	88
4	1841	101	88
5	1851	102	88
6	1833	101	87
7	1846	102	88
8	1828	101	87
9	1839	101	88
10	1823	100	87
11	1833	101	87
12	1815	100	86

6. Conclusion

The problem faced by the company is in terms of determining the optimal selling price based on existing demand for each item and also having problems in determining the optimal production amount of each item it produces for the next 12 periods. In this paper, a pricing model and optimization of the number of multi-item products has been developed using a static pricing strategy in pricing. With this model, the optimal price will be determined and based on the price obtained, as well as the optimal production quantity for each item will be determined using integer linear programming. The goal to be achieved in this research is to maximize the profits obtained by the company, where to achieve that goal there are 3 influential constraints, namely processing time constraints, availability of raw materials, and production capacity.

Based on the solution using the proposed model for the above case, the following results are obtained the price obtained based on the developed model is smaller than the price set by the company at this time. The company's total profit is greater when using the selling price of the model because with the selling price of the model the number of requests for each product increases and makes the profit bigger. The optimal production quantity of each product is equal to the quantity demanded. Price changes are not sensitive to the optimal production quantity.

That is why, there are still many weaknesses in this model. The development for further research can consider several aspects, including the expiration date of the product, the effect of the price of one product on demand for another product, the strategy of environment-dependent pricing and dynamic pricing.

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