Industrial Engineering Letters
ISSN 2224-6096 (Paper) ISSN 2225-0581 (online)
Vol.6, No.8, 2016

Novel Price Sensitive Demand Model with Empirical Results

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Abstract

Demand of commoditized products –for example drinking water and generic pharmaceutical products – depends mainly on price. Therefore, pricing strategy is very important especially for competing suppliers with common retailer. However, although many literatures were studied in pricing strategy, but almost all of those studies did not expand to use empirical data which is very important for applying the findings to real business. To find the point that both manufacturers and a retailer can maximize their own profit in a supply chain, Game theory principle is used. This paper introduces a new parameter concept, the competition intensity of pricing degree, which is an important parameter that we incorporate in our linear price sensitive demand model in order to make the result more applicable. Moreover, we include a case study to show how the finding can be valuable tools for deciding on pricing policy.

Keywords: Demand Model, Competition intensity of price degree, Bargaining Power, Game Theory, Pharmaceutical

1. Introduction

Pricing policy is one of the most important issues for managing products in Today's business. Companies' top management needs to find an appropriate pricing policy to optimize their firm's profit (Michel and Robert, 1992). In addition, because the pricing policy often changes in dynamic competitive business environment, top management then needs to know behavior of competitors to predict prospective outcome profit when a competitor choose a new strategic pricing . Particularly, for non-differentiated product that customers are mostly influenced by price, fastest way to raise a sales is to lower price which the price must be in the point that can achieve the decided outcome profit.

An example of non-differentiated product is commoditized products which their demand mainly depends on price. Commoditized products are the products that there is slightly significant difference in products quality or in consumers' perception, so consumers can substitute a product by another similar products offered by other company at lower prices (Martin and Oliver, 2010) Examples of commoditized product include drinking water and generic pharmaceutical products which must be under the same quality standard, the Food and Drug Administration (FDA) proscriptive regulations. Another example for price sensitive product is the highly substitution products such as competitive brand of antihistamine drug, different generic name but same indications, that consumers can easily switch their demand to the others product when the price is significantly cheaper.

Many commoditized products are sold through various distribution/marketing channels. One of popular channel is distribute through modern trade such as department stores, discount stores or convenient stores which this channel normally sell more than one brand of similar products. To maximize a brand's profit in a store, product manager needs to decide appropriate price and a reasonable product quantity in order to achieve the desire outcome. On the other hand, the retailer needs to know what the retail prices of the two competitive products should be and how many should be ordered for each similar product or each substituted product for making the most profit. In the situation that there have two manufacturers sell their own product to a retailer, all of the parties want to know the critical point where everyone will have the most profit in order to adjust the price strategy to get the most competitive advantage from this situation.

To find the point that both manufacturers and a retailer can maximize their own profit in a supply chain, Game theory principle is used. Solving the equilibrium point by the principle will know how much the wholesale prices should be set and how many pieces the manufacturers should produce for their main distribution channel. The solution can also tell the retailer for which retail price for a product should be set and what the appropriate order quantity for each product is at the critical point.

We derive the equilibrium solutions for a channel that has two manufacturers and one retailer. The wholesale prices, retail prices and all of channel member profits are derived by game theory approach. The results are benchmarked with the ones in Choi (1991), which are among the most widely studied linear demand functions in the literature (McGuire and Staelin, 1983; Jeuland and Shygan, 1988), and discuss in product differentiation issue that is the most important limitation in Choi (1991). The novels of this paper is (1) Demand Model, this paper introduces a new parameter concept, the competition intensity of pricing degree, which is an important parameter that we incorporate in our linear price sensitive demand model in order to make the result more appropriate. (2) An example of case study, this paper presents an example of using the finding in a substitution product. The case study shows how the finding can be a valuable tools for deciding a pricing policy in real business by using the data that can easily find in the market.

From the benefit of linear demand model, this study is decided to develop a price sensitive linear demand model, in which each channel member can easily understand the manufacturers and retailer characteristic trends of an oligopoly competition under the different bargaining power scenarios in more likely the real industry.

From the former limitation in the issue of describing the differentiation, an important parameter, the competition intensity of competitor pricing degree, is added in our demand model to represent how much the consumer sees the difference of the two products. The competition intensity of pricing degree is the level of consumer's price sensitivity of a product that represents the overall consumers' perception of the product in consumer's perspective. In other words, the competition intensity of pricing degree may be represented by the price elasticity of each product demand that includes the effect of the product characteristics such as advertising, service, packaging, brand imaging, etc. Therefore, incorporation of the degree of product differentiation is to including the difference between the competition intensity of pricing degree for both products.

Bargaining Power – using game theoretic analysis: Besides pricing and the product differentiation, bargaining power is a considerable factor that can affect to the product demand of both products (Choi, 1991). Different bargaining power of each player may lead to be an oppressive player which may receive the lowest outcome. Therefore understanding the behavior of each type of each bargaining power scenario is also an important factor for business decision. This paper focuses mainly on three bargaining power scenarios: Manufacturer Stackelberg (MS), Retailer Stackelberg (RS) and Vertical Nash (VN). MS represents the situation where manufacturers have more bargaining power than a retailer. In other words, manufacturers have a chance to make a move before the retailer and act as the leaders in the non-cooperative game. An example of MS scenario is big manufacturers that sell their products to a small or medium retailer. On the other hand, RS represents a situation where the retailer has more bargaining power than manufacturers. An example is the bargaining power of a big chain store on small or medium suppliers. VN represents a no different bargaining power of those manufacturers and the retailer, which can be seen in the situation where manufacturers and the retailer are of the same size.

The rest of this paper is organized as follows. Section 2 briefly reviews previous studies on competing in price sensitive linear demand models. Section 3 presents a linear demand model, cost structures, and the optimization problems for the two manufacturers and one common retailer. Section 4 presents the results and compares the equilibrium solutions with the ones in previous studies. Section 5 concludes the model study. Section 6 applies the finding to second generation antihistamine drug. Section 7 concludes and discusses the future work.

2. Background

This study focuses on price competition under a duopoly manufacturer and a retailer where the manufactures compete with each other under different bargaining power scenarios: Manufacturer Stackelberg, Retailer Stackelberg and Vertical Nash.

2.1 Demand Model

Pricing model was reviewed by Soon 2011 that provided a general review of multi-product pricing models, focusing primarily on those where demands are explicitly dependent on prices. This article also mentioned on types of demand model using in general pricing model and explored numerous studies that use linear price sensitive demand model. Another valuable review article is from Petruzzi and Dada (1999) that reviewed the history of pricing and the newsvendor problem, generalized existing results, and provided a more integrated framework for investigating alternative formulations of the problem.

Although the competition in supply chain management with a price sensitive demand model has been reported extensively in the literature of economics and supply chain, the linear demand function used in previous studies still have disadvantage of directly assessing the effect of product differentiation as describes in Choi (1991). This study aims to find a way that can better describe the effect of product differentiation. Although a linear demand function does not have exactly forecasting properties, possibility be negative quantities value result, it is considered valuable for analysis of the primary interest. Furthermore, linear demand function is an appropriate tool to predict the demand characteristics of a product at a point of time. Generally, the demand quantity of a product, wholesale/ retail prices, the difference of the two products in consumer perspective and the bargaining power may change when the product moves to other stage of its life cycle. Changing is usually because of changes in market environment, the competitor reaction and product innovation along the way. Therefore the product demand model that can fit all of a product life time is hard to find in a dynamic market environment. The linear demand model then is more appropriate than non-linear demand model which cannot represent all of the product life time exactly.

There are several other studies in channel profit with bargaining power. A demand model under one manufacturer and two retailers competing on both price and nonprice factors was studied in Iyer (1998). A model under one manufacturer that sells a commoditized product to two independent retailers was studied in Tsay&Agrawal (2000), where the intensity of competition with respect to each competitive dimension and the degree of cooperation between the retailers were shown to be extremely influential. Kadiyala *et. al*. (1983) showed that a higher share of channel profit was associated with a higher channel power. Kim and Staelin (1999) studied a demand model under two manufacturers and two retailers, and concluded that the activities in store affect the retailers' and manufacturers' profits. Bernstein and Federgruen (2004) introduced an equilibrium stochastic inventory model for a price sensitive oligopoly competition. Tang and Yin (2007) developed a deterministic demand of substitutable products to examine the order quantity and the retail price for a retailer.

Since demand models are fundamental tools in pricing mode, many different formulations have been considered in the literatures. However, one of the most linear demand models that generally uses for pricing study cannot describe differentiation problem. Although there are many linear demand types in numerous researches, those demand models are still not benchmarked to the classical demand model. In this study, the results of our simply linear demand model are compared to most widely studied linear demand model in the literature one. Moreover, an example of using data in academic articles or marketing reports is demonstrated.

2.2 Game Theoretic Analysis: Bargaining Power

For the article concerning different bargaining powers scenarios, Cachon and Netessine (2004) surveyed the application of game theory to supply chain analysis and out-line game-theoretic concepts that have potential for future work application. Choi (1991) proposed three non-cooperative games of these bargaining power scenarios under a duopoly manufacturer and a common retailer. His demand model is $q_i(p_i, p_j) = \propto - bp_i + \theta p_j$, b is competition intensity of pricing degree for product i and θ is competition intensity of pricing degree for product j. He concluded that the difference scenario of bargaining power influence the wholesale prices, retail prices and channel profits. Furthermore, different types of demand model may lead to different trends and dynamics of price competition. Subsequently, McGahan and Ghemawat (1994) applied a game-theoretic model for retaining old customers by service and attracting new customers by price. Lee and Staelin (1997) studied a non-cooperative game under pricing policy with linear and nonlinear demand models. The study showed that the question of using linear or nonlinear demand functions is not as critical as whether the demand function implies vertical strategic substitute (VSS) or vertical strategic complement (VSC). Choi (1996) used subgame-perfect Stackelberg equilibrium to study the effect of bargaining power on four types of channel structures. A limitation of the linear demand model used in Choi 1991 was also discussed as it cannot portray product differentiation problem. In addition to McGuire and Ghemawat (1994) and Choi (1996), several studies in the literature also suggested that different demand functions result in opposite implications for some important issues such as channel leadership and product line pricing. For example, it was shown that under a multiplicative demand function, the follower benefits more than the leader does (Shugan 1985), whereas a linear demand function is shown to be beneficial only to the leader (Choi 1996). Lee and Staelin (1997) explained this contradiction by using the concept of vertical strategic interaction, which depended on the type of demand function.

2.3 Pharmaceutical Products

An example of our finding in substituted product is applied in second generation antihistamine drugs which pricing affects to consumers decision. There are many generic names of the second generation antihistamine drugs that physician prescribes for allergic patient. However, only two brands of the antihistamine are the most normally use in prescription, Clarityne and Zyrtec, which the indication of those product are almost same and physician always orders in the same allergic case. This example is for presenting how this study finding can be applied. In the second generation antihistamine drug market, there are two big brands competing each other's, which one of the brand is stronger and both of the brands have different manufacturer cost. With our finding, we can see what will happen in the equilibrium point that mean, under our assumption, we can find wholesale prices and retail prices of both products which will maximize each player profit. The results present recommended wholesale prices, retail prices and products quantity of those products. Parameters b and θ of each stage of product life cycle will be different parameters to substitute in this model. This case study also presents more complicate case by applying for the case of the two manufacturers have different manufacturer's cost that leads to have two wholesale prices and two retails prices in each scenarios. The example in this part is very useful for business to continue develop our model for using as a deciding tool for planning the next step business strategy.

3. Proposed Demand Model

In this study, there are two competing manufacturers (*i, j*) in the demand model where each manufacturer produces only one commoditized product sold to a common price sensitive retailer. There is only one retailer in the model in order to eliminate the effect of retailer completion. In this study model, linear price sensitive demand model form Choi(1991) is modified but keeps the same definition of parameters. Like Lee&Stalin(1994), Iyer(1998) the following assumptions have been made: (1) the demand structure is symmetric and decreasing in its own retail price and increasing in the competitor retail price; (2) both products i and j have the same local demand factors; (3) decreasing retail price will affect product demands as follows: first, a group of customer switches to another product, and next, a new consumer group comes in because of price attraction. The opposite happens when the retail price increases; (4) all of the players in our model have symmetric information.

The following notations are used to develop the mathematical model ($i = 1, 2$; $j = 3-i$):

- q_i the retailer ordering quantity of brand i at price p_i
- $\propto$ local demand factors of the product i and j
- b competition intensity degree for product i
- θ competition intensity degree for product j
- w_i wholesale price for product i
- c_i manufacturer cost for product i
- m_i retailer margin for product i

The developed linear duopoly demand model is given by

$$q_i(p_i, p_j) = \propto - bp_i - \theta(p_i - p_j) \quad \text{or}$$

$$q_i(p_i, p_j) = \propto - bp_i - \theta p_i + \theta p_j \,, \qquad (1)$$

where $\propto > 0$, $b > \theta > 0$ as explained in Jeuland & Shugan (1988) and Lu. *et. al.*(2011). The competition intensity of pricing degree shows the competition ability on each product price, where the difference (b-θ) relates to the degree of product differentiation. In (1), the product demand depends on its own market base, own retail price, competitor retail price and the competition intensity degree for product i and j. Unlike Choi (1991)'s demand model, one more term of the competition intensity degree of competitor, θ, has been added to demand model in this study. The degree θ is added based on the fact that the difference of competitor pricing has significant effect on manufacturer i's demand in price sensitive market. Profit functions of the manufacturers and the retailer can be shown as follows:

Manufacturer i's profit function is

$$\pi_{M_i} = (w_i - c_i)q_i(p_i, p_j). \qquad (2)$$

Retailer's profit function is

$$\pi_R = \sum_{i=1}^{2} m_i q_i(p_i, p_j). \tag{3}$$

4. Game Theoretic Analysis

Both manufacturers and the retailer are assumed to seek to maximize their own profits and there is no cooperation between channel members similar to the most common institutional arrangement of the channel structure under consideration. Therefore, the wholesale prices and retail prices solving by game theory in this paper represent the best prices and product quantities for all players in the game under each bargaining power scenario.

To understand the pricing decision behavior of each type of bargaining power scenarios, a game-theoretical approach is used as follows:

Manufacturer Stackelberg (MS): the manufacturers have the first-mover advantage. This scenario will be solved by the backwards induction method, where the retailer's reaction function is solved first, and then each manufacturer takes the retailer's reaction function as part of their decisions but chooses its wholesale price based on observed competitor's price. Subsequently, the retailer uses the wholesale prices to determine the retail price of each product to maximize the total profit from both brands.

Specifically, to solve the MS scenario, the manufacturers must take the retailer's reaction function for their decisions. Therefore, retailer's reaction function is solved first. The retailer chooses the retail prices from

$$p_i^* \in \arg\max_{p_i} \prod_R (p_i, p_j^* | w_i, w_j), \tag{4}$$

where p_i^* and p_j^* are the retailer prices that maximize the retailer's profit. Given the wholesale prices of both products, the retailer's reaction function can be derived from the first-order conditions of (3),

$$0 = \frac{\partial \prod_R}{\partial \prod_{p_i}} = \alpha - 2bp_i - 2\theta p_i + \theta p_j + bw_i + \theta w_i. \tag{5}$$

The negative definite Hessian is checked: $\partial\prod_R^2/\partial p_i^2$=-$2b$-$2\theta$, $\partial\prod_R^2/\partial p_i p_j$ =2θ, $\partial\prod_R^2/\partial p_j p_i$ =2θ and $\partial\prod_R^2/\partial p_j^2$= -$2b$-$2\theta$, where $b > \theta > 0$. The equation satisfies the second-order condition for a maximum.

From (5), the retailer's reaction function is

$$p_i = \frac{w_i}{2} + \frac{\alpha}{2b}. \tag{6}$$

From (6), the manufacturers choose their wholesale prices from

$$w_i^* \in \arg\max_{w_i} \prod_{M_i} (w_i, w_j^*). \tag{7}$$

The manufacturers' wholesale prices can be derived from the first-order conditions of the respective manufacturers' profit maximization problems:

$$0 = \frac{\partial \prod_{M_i}}{\partial \prod_{w_i}} = \frac{1}{2b}(\alpha b - 2w_i b(b+\theta) + bw_j\theta + c_i b(b+\theta)). \tag{8}$$

From (8), the MS wholesale prices and retail prices are

$$w_i = \frac{\propto}{2b+\theta} + \frac{2c_i(b+\theta)^2 + c_j\theta(b+\theta)}{(2b+3\theta)(2b+\theta)}, \; i, j = 1,2, j = 3\text{-}i$$

$$p_i = \frac{\alpha}{2b} + \frac{\alpha(2b+3\theta) + 2c_i(b+\theta)^2 + c_j\theta(b+\theta)}{2(2b+3\theta)(2b+\theta)}. \tag{9}$$

To compare the results with the ones in Choi (1991), manufacturing cost condition is set as $c_i = c_j = c$. Therefore, under this symmetry condition, the MS wholesale and retail prices are

$$w_i = w_j = \frac{\alpha + c(b+\theta)}{2b+\theta},$$

$$p_i = p_j = \frac{\alpha(3b+\theta) + bc(b+\theta)}{2b(2b+\theta)}, \tag{10}$$

where the prices always have positive values since the competition intensity of degrees for product are set as $b > \theta > 0$.

To get the positive results of manufacturers' profits and retailer's profit, the contribution margin for manufacturer i can be derived as

$$w_i - c_i = \frac{\alpha - bc}{2b+\theta}. \quad (11)$$

For manufacturers to be profitable, the contribution margin has to be nonnegative. Therefore, following condition is set as an upper bound of production cost:

$$c_i \leq \frac{\alpha}{3b+\theta}. \quad (12)$$

Retailer Stackelberg (RS): the retailer has the first mover advantage. Similarly, the backwards induction method will be used to solve this problem. The manufacturers' reaction functions is solved first, and then the retailer uses the manufacturers' reaction functions to choose the retail prices of each product based on the retailer's margin on each product and observed retail prices of the competing brand.

Specifically, to solve the RS scenario, the retailer takes manufacturers' reaction functions as part of its decision. Therefore, manufacturers' reaction functions have to be solved first. The manufacturers choose their wholesale prices from

$$w_i^* \in \arg\max_{w_i} \prod_{M_i}(w_i, w_j^* | p_i, p_j), \quad (13)$$

where w_i^* *and* w_j^* are the manufacturers' wholesale prices that maximize each manufacture's profit.

The manufacturers' reaction functions can be derived from the following first-order conditions:

$$0 = \frac{\partial \prod_{M_i}}{\partial \prod_{w_i}} = q_i + (w_i - c_i)\frac{\partial \prod_{q_i}}{\partial \prod_{p_i}}\frac{\partial \prod_{p_i}}{\partial \prod_{w_i}}. \quad (14)$$

The negative definite Hessian is checked: $\partial \prod_{M_i}^2 / \partial w_i^2$ =-b-θ, $\partial \prod_{w_i}^2 / \partial w_i \partial w_j$ =0, $\partial \prod_{w_i}^2 / \partial w_j \partial w_i$ =0 and $\partial \prod_{w_i}^2 / \partial w_j^2$= -b-θ, where $b > \theta > 0$. The equation satisfies second-order condition for a maximum. Thus, this implies that a solution of (14) is a Nash equilibrium between the two manufacturers.

From the manufacturers' reaction functions in (14), wholesale prices can be derived from the following first-order conditions of the respective manufacturers' profit maximization problem:

$$w_i = \frac{1}{(b+\theta)}(\alpha - (b+\theta)p_i + c_i(b+\theta) + \theta p_j). \quad (15)$$

From the manufacturers' reaction functions (15), the retailer chooses retail prices from

$$p_i^* \in \arg\max_{p_i} \prod_R (p_i, p_j^*). \quad (16)$$

The retail prices can be derived from the first-order conditions of the respective retailer's profit maximization problem:

$$0 = \frac{\partial \prod_R}{\partial \prod_{p_i}} = \left(1 - \frac{\partial w_i(p_i,p_j)}{\partial p_i}\right) q_i(p_i,p_j) + \left(p_i - w_i(p_i,p_j)\right)\frac{\partial q_i}{\partial p_i}(p_i,p_j) + \left(-\frac{\partial w_j(p_i,p_j)}{\partial p_i}\right) q_j(p_i,p_j) + \left(p_j - w_j(p_i,p_j)\right)\frac{\partial q_j}{\partial p_i}(p_i,p_j) \quad (17)$$

From (17), the RS retail prices and wholesale prices are

$$p_i = \frac{A_i}{B-C}, \quad (18)$$

$$w_i = \frac{\alpha + c_i(b+\theta)}{b+\theta} - \left[\frac{A_i(b+\theta) - A_j\theta}{(b+\theta)(B-C)}\right], \quad (19)$$

where

$A_i = \alpha(3b+\theta) + c_i b(b+2\theta) + c_i\theta^2 - c_j\theta(b+\theta)$

$B = (2b+2\theta)^2 + 2\theta^2$

$C = 6\theta(b+\theta)$

The retailer margins can be derived from

$$m_i = p_i - w_i, \quad (20)$$

$$m_i = \frac{2A_i(b+\theta) - A_J\theta}{(b+\theta)(B-C)} - \frac{\alpha + c_i(b+\theta)}{(b+\theta)}. \quad (21)$$

To get the positive results of the retailer's margin. Therefore, the following condition is set as an upper bound of manufacturer cost:

$$c_i \leq \frac{\propto(3b^2 + 5b\theta + \theta^2 - 1)}{b(2b+\theta)(b+\theta)}. \quad (22)$$

When manufacturing cost is assumed to be equal, $c_i = c_j = c$, the RS wholesale and retail prices are

$$w_i = w_j = \frac{\alpha+c(b+\theta)}{b+\theta} - \frac{bA}{(B-C)(b+\theta)},$$
$$p_i = p_j = \frac{A}{B-C},$$

Therefore, the retailer margin is

$$m_i = m_j = \frac{\alpha}{2b} - \frac{c(2b^2+3b\theta-\theta^2)}{2(2b+\theta)(b+\theta)}. \tag{23}$$

Vertical Nash (VN): the manufacturers and the retailer have equal power. Each manufacturer chooses its wholesale price subject to the retailer's margins on individual products and observed retail prices of the competing brand. The retailer determines the margin of each brand subject to the respective wholesale prices.

Specifically, to solve the VN scenario, the first-order conditions for this equilibrium that come from retailer and manufacturers profit maximization conditions from the MS and RS scenarios are used:

$$0 = \frac{\partial \Pi_R}{\partial \Pi_{p_i}} = \alpha - 2bp_i - 2\theta p_i + \theta p_j + bw_i + \theta w_i,$$
$$0 = \frac{\partial \Pi_{M_i}}{\partial \Pi_{w_i}} = q_i + (w_i - c_i)\frac{\partial \Pi_{q_i}}{\partial \Pi_{p_i}}\frac{\partial \Pi_{p_i}}{\partial \Pi_{w_i}}.$$

Therefore, the VN retail prices and wholesale prices are

$$p_i = \frac{D_i+E}{F}, \tag{24}$$
$$w_i = \frac{\alpha+c_i(b+\theta)}{b+\theta} - \frac{D_i+E}{F} + \theta\frac{D_j+E}{F(b+\theta)}, \tag{25}$$

where

$D_i = (b+\theta)[3(\alpha+bc_i)(b+\theta)+\theta(\alpha+bc_j)]$,

$E = \alpha b(3b+4\theta)$, $F = b(3b+4\theta)(3b+2\theta)$.

Note that, the condition in (14) must be satisfied for demand and contribution margin to be non-negative.

When manufacturing cost is assumed to be equal, $c_i = c_j = c$, the VN wholesale prices and retail prices are

$$w_i = w_j = \frac{\alpha+(b+\theta)c}{b+\theta} - \left[\frac{(\alpha+bc)(b+\theta)+\alpha b}{b(3b+2\theta)}\right]\left[\frac{b}{b+\theta}\right],$$
$$p_i = p_j = \frac{(\alpha+bc)(b+\theta)+\alpha b}{b(3b+2\theta)}. \tag{26}$$

The comparison of wholesale prices and retail prices from this study with the ones in Choi(1991) for all bargaining power are shown in Table 1.

TABLE 1

COMPARISON OF WHOLESALE AND RETAIL PRICES IN DIFFERENT BARGAINING POWER

	Choi (1991)	This paper
	Manufacturer Stackelberg	
w_i	$\frac{\alpha+bc}{2b-\theta}$	$\frac{\alpha+c(b+\theta)}{(2b+\theta)}$
p_i	$\frac{\alpha(3b-2\theta)+bc(b-\theta)}{2(2b-\theta)(b-\theta)}$	$\frac{\alpha(3b+\theta)+bc(b+\theta)}{2b(2b+\theta)}$
	Retailer Stackelberg	
w_i	$\frac{\alpha+(3b-\theta)c}{2(2b-\theta)}$	$\frac{(\alpha+c(b+\theta))(B-C)-bA}{(b+\theta)(B-C)}$
p_i	$\frac{\alpha(3b-2\theta)+bc(b-\theta)}{2(2b-\theta)(b-\theta)}$	$\frac{A}{B-C}$
	Vertical Nash	
w_i	$\frac{\alpha+2bc}{3b-\theta}$	$\frac{\alpha+(b+\theta)c}{b+\theta} - \left[\frac{(\alpha+bc)(b+\theta)+\alpha b}{b(3b+2\theta)}\right]\left[\frac{b}{b+\theta}\right]$
p_i	$\frac{\alpha(2b-\theta)+bc(b-\theta)}{(3b-\theta)(b-\theta)}$	$\frac{(\alpha+bc)(b+\theta)+\alpha b}{b(3b+2\theta)}$

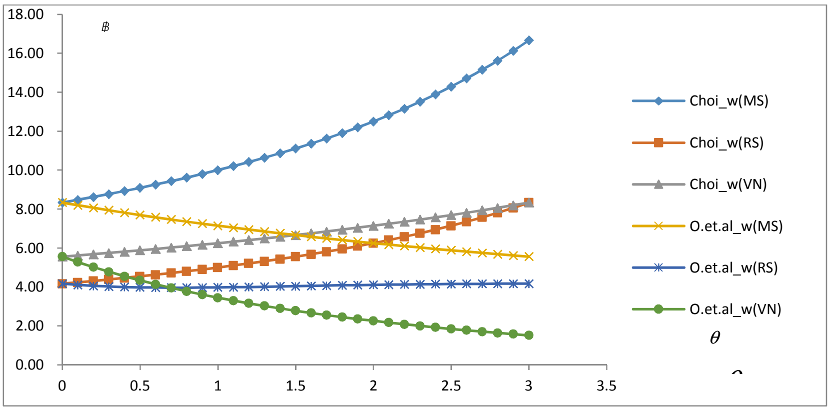
5. Analytical Results

This section discusses analytical results from the proposed price sensitive demand model with those in Choi(1991) based on three bargaining power scenarios. The difference of this study demand model from Choi (1991) is the last term of linear demand model. The difference of the last term of this study demand model,$(-\theta(p_i - p_j))$, and Choi(1991) demand model, $(+\theta p_j)$, is, $(-\theta p_i)$. Therefore, demand model in this study considers the effect of the difference of the both product prices instead of consider only in competitor price. It means the competition intensity of pricing degree for product j, θ, affect on product i also.

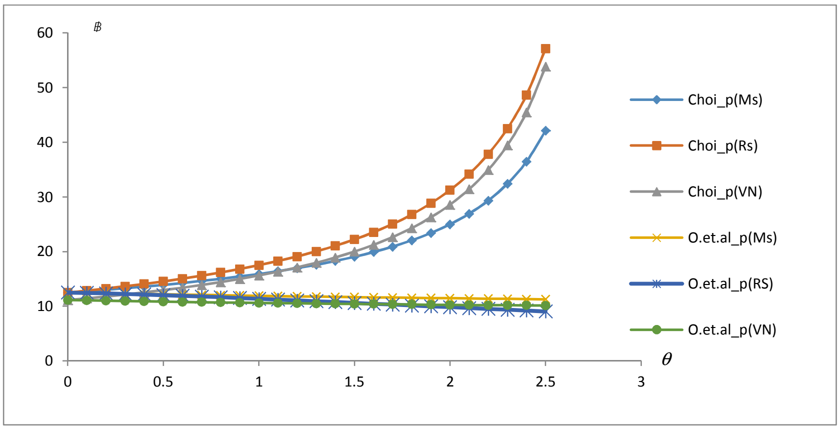
From Table 1, when θ closes to zero, the result of Choi (1991) and this study are the same. It shows that when the products are different enough (θ closes to zero, $b-\theta$ or the degree of differentiation is big), both products will not interfere each other.

In order to compare the trend of product differentiation to those in Choi (1991), parameters in our linear demand model are set as follows: $\alpha = 50$, $b = 3$ and $0 < \theta < 3$. Because the difference of $b-\theta$ shows the degree of product differentiation; therefore, the smaller value of θ represents the more product differentiation.

Figure 1 presents the characteristics of wholesale and retail prices in different bargaining power scenarios. Figure 1 (a) shows the opposite trends between results from Choi's model and this study. Using traditional linear price sensitive demand models, the wholesale prices in different bargaining power scenarios trend to increase when the competition intensity of competitor degree, θ, increases. In contrast, resulting wholesale prices in using this study demand model trend to decrease when θ increases that represents more reality. The decreasing trend shows that a wholesale price of a manufacturer product will decrease when the ability of competitors to compete with the former manufacturer in this industry increases. In other words, decreased degree of product differentiation leads to a decrease in wholesale prices in the supply chain. Figure 1 (b) compares the retail price trend from this model with Choi's when θ increases. These trends yield similar results to the wholesale price trends shown in Figure 1 (a).

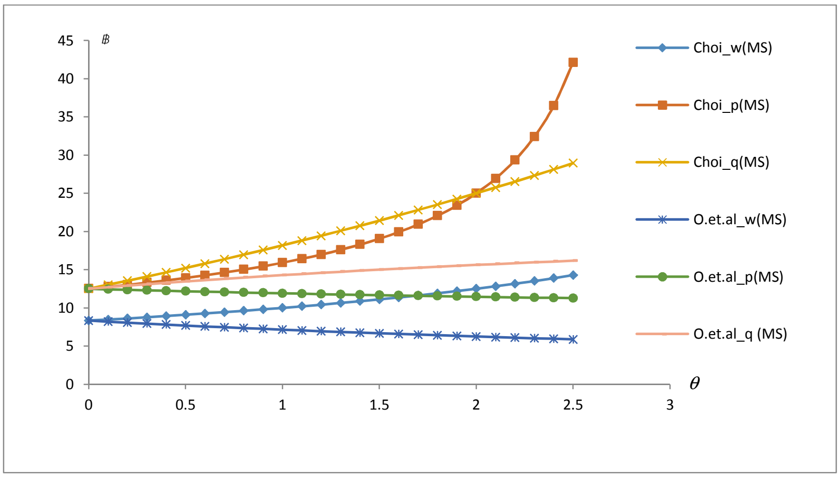


(1 a) Wholesale prices

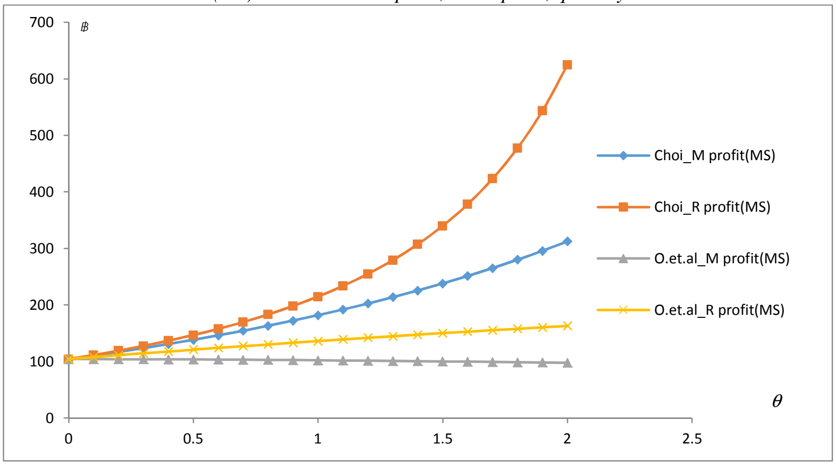


(1 b)Retail Prices

Figure 1. Comparison of wholesale price and retail price with Choi (1991) for three types of bargaining power.



(2 a) MS: wholesale price, retail price, quantity

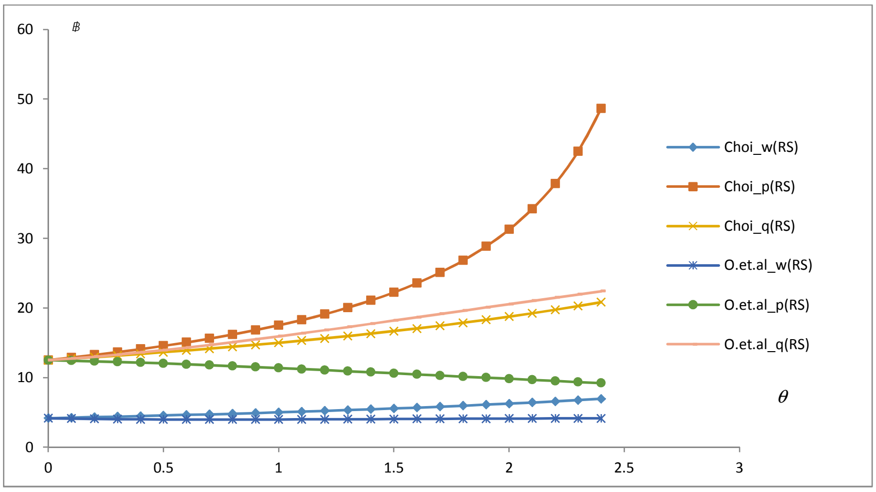


(2 b) MS: manufacturer profit and retailer profit.

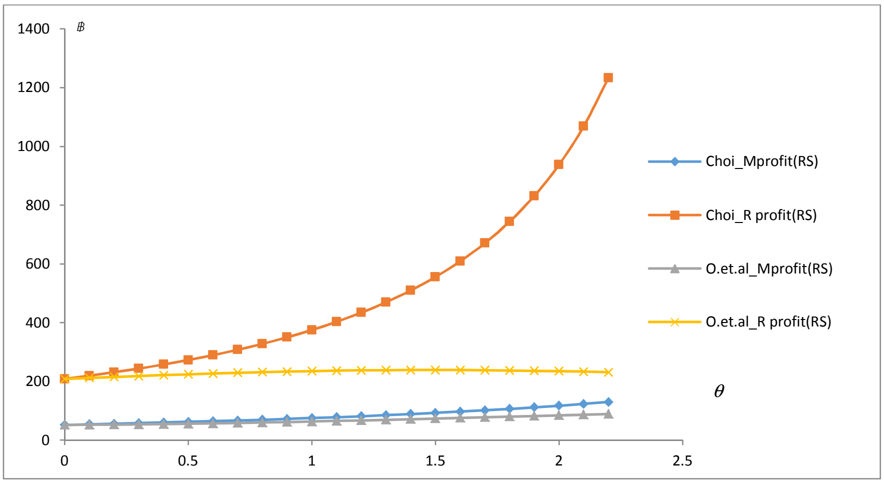
Figure 2. Comparison of Manufacturer Stackelberg solutions with Choi [3]: wholesale price, retail price, quantity, manufacturer profit and retailer profit.

The comparison of Choi and this study in MS results is shown in Figure 2. Figure 2(a) shows the wholesale prices, retail prices and quantities of each product. The Figure shows that product demand of Choi's model increases when θ increases. On the contrary, the wholesale price and retail, when uses this study demand model, decreases slightly, and the product demand increases as the competition intensity of competitor degree increases.

It shows that when the two products have less differentiation, the retail prices will decrease. However, at that situation the demand quantity graphs trend to increase when retail price decreases. It can describe as general that demand increases when retail price decreases which according to the assumption 3. Figure 2(b) compares the manufacturers and retailer's profits when use this study demand model and Choi's demand model. Using Choi's demand model, both manufacturers and retailer profits increase when products have less differentiation. In contrast, using this study demand model, when products are less differentiated the retailer profit from our model increases slightly, whereas the manufacture profit decreases slightly. Moreover, the same results from this study and Choi's study is the retailer still gains more benefit than manufacturers, even when manufacturers have more bargaining power. However, the retailer profit will close to the manufacturers profit when the two products are more differentiation.



(3 a) RS: wholesale price, retail price, quantity



(3 b) RS: manufacturer profit and retailer profit

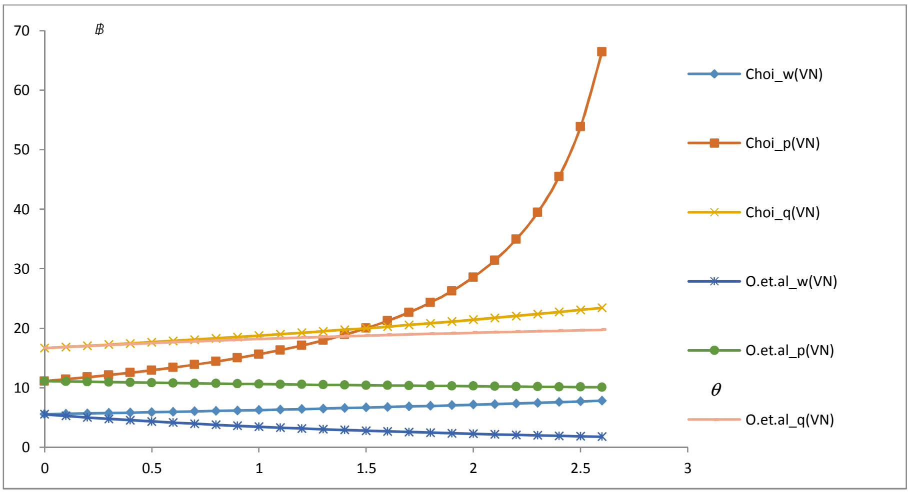
Figure 3. Comparison of Retailer Stackelberg solutions with Choi(1991): wholesale price, retail price, quantity, manufacturer profit and retailer profit.

Figure 3(a) and 3(b) compare the results in RS scenario. Only retail price and retailer profit show the opposite trend as using Choi's demand model. In Figure 3(a), when products have more differentiation, retail prices using Choi's demand model decreases while the retail prices using this study demand model increases. This trend also shows in retailer profits as in Figure 3(b). Therefore, in RS scenarios, the demand model in this study can explain the realistic trend more in product differentiation.

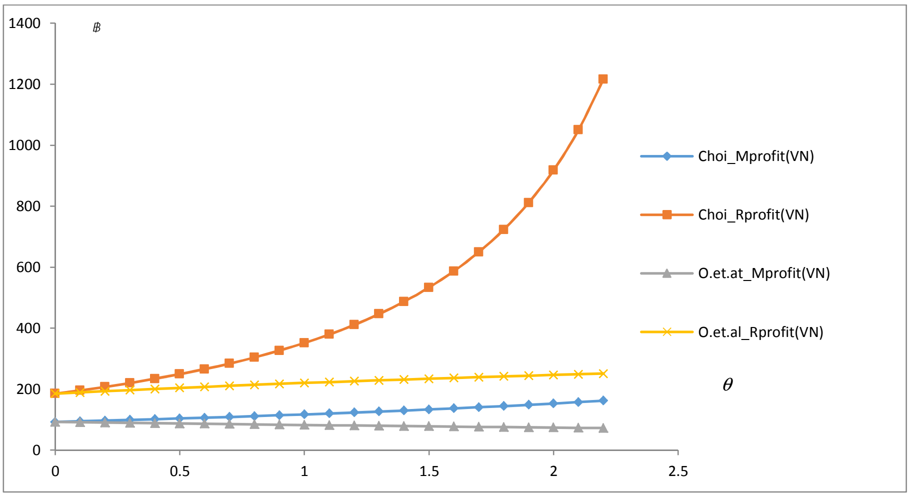
From Figure 3, the results can be interpreted that when manufacturers compete with each other and have to sell their products to a common retailer, the bargaining power lies on the retailer side, the retailer gains more profit than manufacturers. Moreover, in Figure 3, it also shows a higher retailer profit in the RS scenario than that in the retailer profit in MS scenario. The figure also shows the demand quantities from both demand models are not much difference.

The results of the Vertical Nash scenario are shown in Figure 4 that shows similar characteristics of the retailer profit to those in the MS and RS scenarios. The retailer gains more profit than manufacturers because the products demand significantly increases more than the change of retailer's contribution margin. Although the degree of differentiation decreases, the product demand still increases. Therefore, the retailer still has more profit than the manufacturers.

The demand quantity of all scenarios both using Choi's demand model and this study demand model trend to increase when the products less differentiation. In addition, all of the results of demand quantity at the equilibrium point less than the value of market base. Therefore, the finding shows that, at the equilibrium point, both manufacturers will better consider to use the policy that sell their products quantity less than the market demand quantity. The second-generation anti-histamine in section 4 will show an example of recommended quantity that can maximize the supply chain profit.



(4 a) VN: wholesale price, retail price, quantity



(4 b) VN: manufacturer profit and retailer profit

Figure 4. Comparison of vertical Nash solutions with Choi(1991): wholesale price, retail price, quantity, manufacturer profit and retailer profit.

Table 2 compares the results between this study with Choi's demand model when 1<θ<1.5, b =3. Wholesale prices, retail margin, manufacturer profits and retailer profits are similar order when compare with Choi's study. The Table shows different ranging in the retail price and the demand quantity. However, outside this range, the retail price become to $p^{MS} > p^{VN} > p^{RS}$ which totally opposite of Choi(1991) results. For the demand quantity, in Table 2, demand quantity is highest in RS scenario, but the ranging is changed to $p^{VN} > p^{RS} > p^{MS}$ when θ >1.5, b =3. It can explain that differentiation affects to the characteristics of the competition.

TABLE 2

COMPARISON RESULTS FROM THE THREE SCENARIOS

	CHOI[3]	THIS PAPER
Wholesale price	$w^{MS} > w^{VN} > w^{RS}$	$w^{MS} > w^{VN} > w^{RS}$
Retail price	$p^{RS} > p^{VN} > p^{MS}$	$p^{MS} > p^{RS} > p^{VN}$
Retailer margin	$m^{RS} > m^{VN} > m^{MS}$	$m^{RS} > m^{VN} > m^{MS}$
Demand quantity	$q^{MS} > q^{VN} > q^{RS}$	$q^{RS} > q^{VN} > q^{MS}$
Manufacturer profit	$\prod_M^{MS} > \prod_M^{VN} > \prod_M^{RS}$	$\prod_M^{MS} > \prod_M^{VN} > \prod_M^{RS}$
Retailer Profit	$\prod_R^{RS} > \prod_R^{VN} > \prod_R^{MS}$	$\prod_R^{RS} > \prod_R^{VN} > \prod_R^{MS}$

When *1<θ<1.5, b =3*

6. Case Study

The second generation antihistamine drugs have been used for allergic treatment and become a biggest share in pharmaceutical industry. Two brands those are well known in the United State are Clarityne (introduced in 1993) and Zyrtec (introduced in 1996) which have total share of the second generation antihistamine market in the United States around 50% (36.43% for Clarityne and 13.30% for Zyrtec). The data in this study obtain from Narayanan *et al* (2005) that studied the antihistamines market in the United State during 1993-2001. The average retail price of Clarityne and Zyrtec are \$48 and \$41 per prescription and the total prescription is around 2,000 per month. Narayanan *et al* (2005) found that the own price elasticity of Clarityne and Zyrtec are -2.61 and -2.25. We assume the manufacturer costs are 20% of the product retail prices, local demand factors of each brand is 1,000 prescriptions per month, coefficient of Clarityne and Zyrtec are multiplied by 10 of price elasticity value and both of the second generation antihistamine drugs fit in our price sensitive linear demand model. Manufacturer brand 1 is Clarityne and manufacturer brand 2 is Zyrtec. Now we can find wholesale prices, retail prices, manufacturer profits and retailer profits in three different bargaining power scenarios from the closed form solution above that by substitute the following parameters α=1000, b=26.1, θ=22.5, c1=9.6, c2=8.2 in equation (9), (18), (19), (24), (25) for finding the wholesale prices and retail prices, the substitute the retail prices in equation (1) for getting demand quantities, and then substitute the demand quantities in equation (2), (3) for finding the manufacturer's profits and retailer's profits.

In this case study, since the price elasticity of Clarityne is more than Zyrtec, and from the data, Clarityne retailer price and demand quantity are also higher than Zyrtec, it implies that Clarityne's brand is stronger than Zyrtec (Walter & Christopher 2008, Patrick&Gerry 2010). In addition, in this case, we assume the cost of Clarityne is higher than Zyrtec because stronger brand in this case pay more for build brand image. Therefore, now, Zyrtec is the following brand that tries to make more market share and more profit. All of player need to know what will happen at equilibrium point in order to prepare their strategies. Preparing the strategy means changing some parameters such as decreasing manufacturer's cost or increasing the intensity of competition degree to reach the product target. Knowing what will happen under perfect information condition is extreme important for competing. In this example, manufacturer's costs are not equal, the wholesale prices and retail prices of Clarityne and Zyrtec are not similar. The results are shown in Table 3

TABLE 3
CASE STUDY: COMPARISON RESULTS FROM THE THREE SCENARIOS

	MS	RS	VN
M1Wholesale price	19.46	13.83	18.43
M2Wholesale price	18.89	14.25	17.63
M1Retail price	28.89	29.37	21.52
M2Retail price	28.60	28.13	21.11
M1Manufacturer margin	9.86	4.23	8.83
M2Manufacturer margin	10.69	6.05	9.43
M1Retailer margin	9.43	15.53	3.08
M2Retailer margin	9.71	13.88	3.49
M1Demand quantity	239.63	205.63	429.35
M2Demand quantity	259.84	293.84	458.09
M1Manufacturer profit	2363.13	870.06	3793.00
M2Manufacturer profit	2778.48	1776.60	4313.87
Retailer Profit	4782.07	7272.79	2919.59
M1Market share (\$)	6 922.91	6 039.35	9 239.61
M2 Market share (\$)	7 431.42	8 265.72	9 670.28

Table 3 shows the results that optimize profits for all players under different scenarios. It means under the assumptions that all players have perfect information and each player wants to maximize own profit, they will set their price as Table 3. In other word, instead describing in no cooperation situation under the perfect information assumption, we can describe the situation in the real competition under the concept of cooperation. Cooperation in this case may be use the concept of information sharing for coordinate supply chain. Clarityne and Zyrtec may apply this model to know own market share in the certain areas.

Manufacturer Stackelberg:

The results in table III implied that in Manufacturer act as leader scenario, at equilibrium point that shows in table III, when Clarityne and Zyrtec are completing and there is only one strong retailer at that area, Clarityne, which is assumed to be the higher cost, will be sold at more expensive price in both wholesale price and retail price than Zyrtec which both of the wholesale prices and the retail prices are higher than other scenarios. It shows that, in this scenario, manufacturer can push the manufacturer cost to their selling prices which retailer must accept the higher prices manufacturers charge. With the scenario that manufacturer act as a leader, both of manufacturers profit are higher than other scenarios while retailer margins are less than those in retailer Stackelberg. Because of higher price, Clarityne demand quantity is lower than Zyrtec then this situation leads to Clarityne has lower manufacturer profit. That means Clarityne which is the brand leader will loss the market leader under this condition and also gets profit less than Zyrtec. Therefore, if Clarityne want to be the market share leader, Clarityne have to plan to change some parameters such as decrease manufacturer cost or make the product more different. However, in MS scenario, the total manufacturer profit is higher than those in Retailer Stackelberg scenario.

To conclude, in manufacturer Stackelberg scenario, manufacturer use the advantage of more bargaining power to raise their wholesale price whereas retailer sells both products by concerning retailer margin. Because this model is price sensitive demand, Claityne which sell at the higher price will have the lower demand quantity that make Clarityne loss in market share leader in second generation antihistamine. In case of Clarityne want to be the market share leader in second generation antihistamine, Clarityne have to change some parameters for moving to the new equilibrium.

RETAILER STACKELBERG:

When comparing the results with MS, Clarityne's wholesale price in RS is much lower while Clarityne's retail price is slightly higher. In addition, comparing Clarityne and Zyrtec wholesale price, Clarityne wholesales price is lower than Zyrtec although Clarityne brand is stronger. In contrast, Clarityne retail price in this scenario is higher than Zyrtec. It shows that when retailer has more bargaining power, retailer trends to oppress the manufacturers especially Clarityne which has more price elasticity to maximized retailer profit. It occurs because retailer knows that some consumers prefer brand name product (stronger brand, more price elasticity brand) if the brand name product's price is not much different to another brand. Therefore, retailer maximizes own profit by lowering the wholesale price and raising the retail price in stronger brand. Retailer chooses pricing strategy not only in Clarityne but also in Zyrtec. Zyrtec retail price in RS scenario is lowers than in MS scenario. Lowering Zyrtec retail price leads to make more retailer profit comparing with in MS scenario. Therefore, retailer can make more profit from Zyrtec by raising Zyrtec demand by lower price strategy. Moreover, retailer also uses the advantage of more bargaining power to lowering the wholesale price in order to make more profit for both brands.

Because of the retailer strategies, manufacturer profit of this scenario in both of Clarityne and Zyrtec are less than in MS scenario while retailer can make nearly double profits from this scenario.

To conclude, in retailer Stackelberg scenario, retailer uses the bargaining power advantage lowering the wholesale prices and raises their retail prices whereas manufacture especially with more price elasticity will be in recession situation at equilibrium.

Vertical Nash

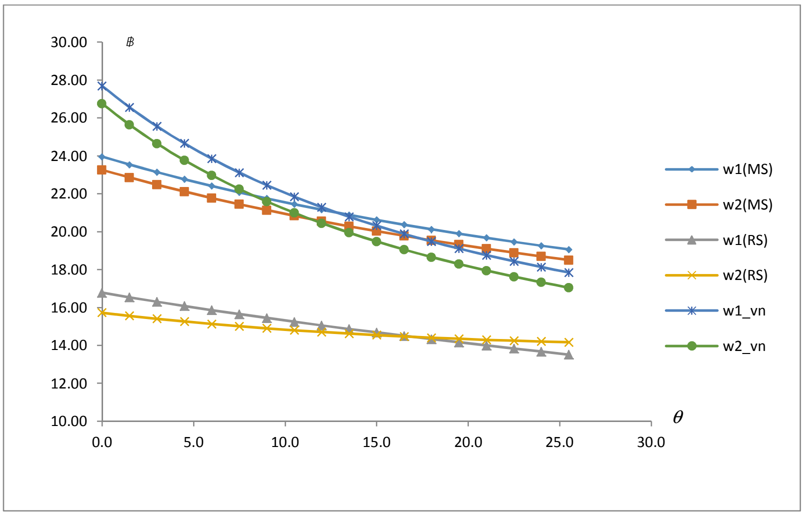
In VN scenario, although wholesale price, retail price, and manufacturer margin are lower than those in MS scenario, manufacturers have the most profit comparing with others scenarios because retailer sell both Clarityne and Zyrtec at the cheapest price in order to raise both brands demand. In other word, with not different bargaining power, retailer will maximize retailer profit by demand volume that also benefit to manufacturers.

To conclude, the strategy uses in VN scenario is lowering the retail price in order to raise both product volumes for maximizing each player profit.

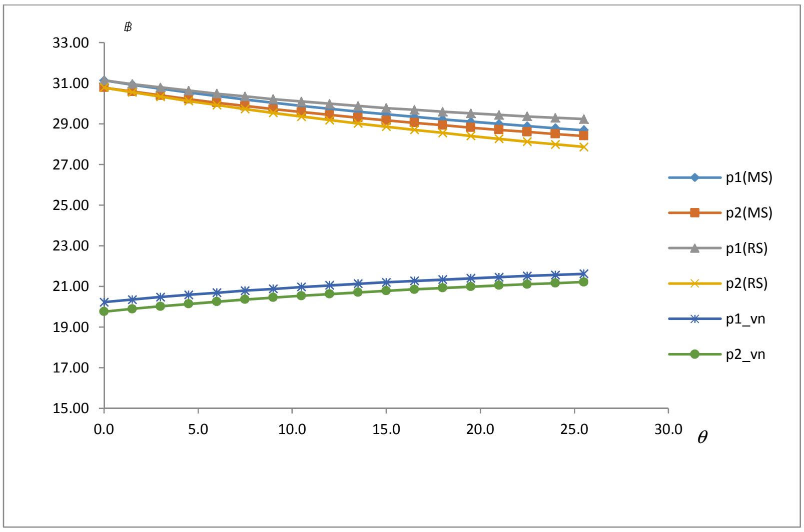
The characteristics of each player at equilibrium point are investigated, for describing the effect of differentiation; we assume that Zyrtec is deciding to get more benefit from lowering the intensity of competition degree, such as decreasing brand image which leads to lowering price elasticity of Zyrtec. In this case we assume that manufacturer cost does not change, therefore we will see only the effect of differentiation in this situation.

The results classify by bargaining power scenario are shown in Figure 5. In order to investigate the differentiation effect for this example, we vary Zyrtec intensity of competition coefficient from 0-30.

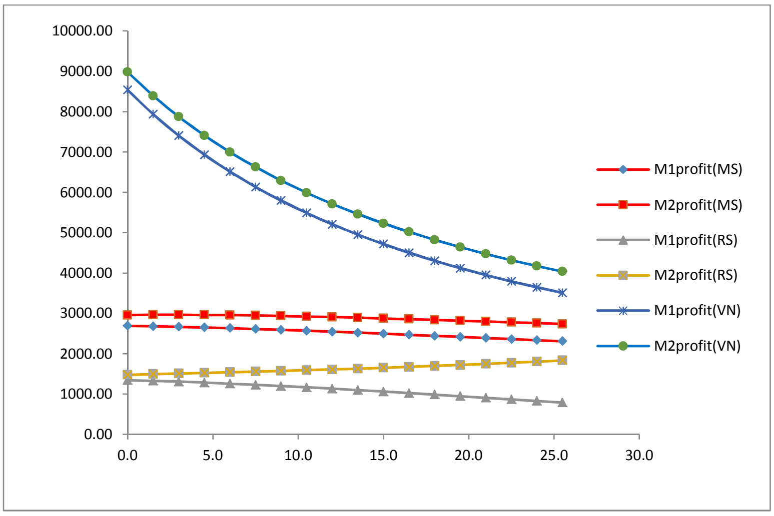
Figure 5(a) and 5(b) show wholesale prices and retail prices in different bargaining power scenarios that vary Zyrtec intensity of competition coefficient from 0-30. But in this case Zyrtec need to know that when Zyrtec intensity of competition coefficient increases, will Zyrtec get more profit? Figure (5c) which shows manufacturers profit trend when Zyrtec intensity of competition coefficient changes represents that only RS scenario meet the Zyrtec aim. That is in RS scenario, when Zyrtec increases own intensity of competition coefficient, Zyrtec profit will receive more. But in MS and VN, increasing Zyrtec intensity of competition coefficient leads to decrease Zyrtec profit. Therefore, if Zyrtec wants to get more profit, Zyrtec has to know that in this case manufacturer or retailer has more bargaining power. If this case is RS scenario, lowering own intensity of competition degree will increase Zyrtec profit.



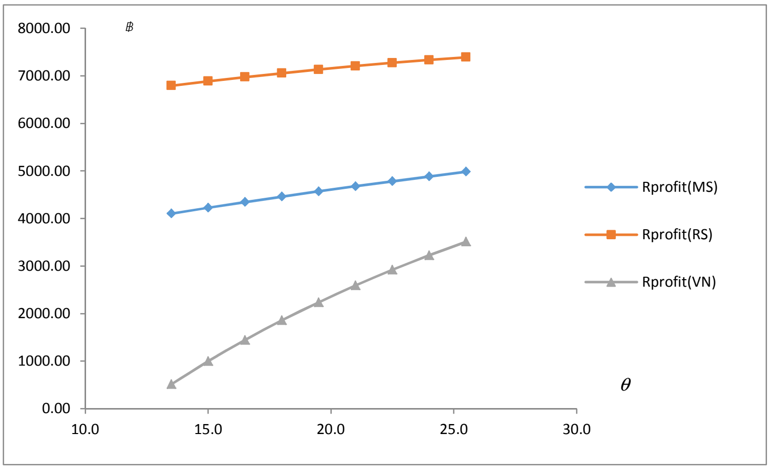
(5a)Case study: wholesale prices in the three different bargaining power scenarios.



(5 b)Case study: Retail prices in the three different bargaining power scenarios.



(5c) Case study: manufacturer profits in the three different bargaining power scenarios



(5d) Case study: retailer profits in the three different bargaining power scenarios.

7. Conclusion and Discussion

General conclusions of the model: Pricing competition decisions under a duopoly manufacturer and a retailer where the manufactures compete with each other under different bargaining power scenarios are analyzed under the assumption that (1) the demand structure is symmetric and decreasing in its own retail price and increasing in the competitor retail price; (2) both products i and j have the same local demand factors; (3) decreasing retail price will affect product demands as follows: first, a group of customer switches to another product, and next, a new consumer group comes in because of price attraction. The opposite happens when the retail price increases; (4) all of the players in our model have symmetric information. In this study, firstly, we present a demand model and solve for the closed-form solutions to the optimal wholesale prices, retail prices, manufacturers profit and retailer profit. Then, the equilibrium solutions are compared with an existing linear demand model in previous studies under the same condition. The results show that our linear demand model is more intuitive and interpretable than the existing linear demand model. Moreover, we found the different ranging of retail price and demand quantity when compare this study results with previous studies. We also agree with the previous studies that product differentiation and bargaining power affects to the characteristic of competition that compared by figures in each bargaining power scenarios. This finding will useful when a manufacturer that sell commoditized product need to know what will happen if the degree of differentiation changes. The equilibrium points which can calculate from table 1 will tell the way to maximize channel profit point. Manufacturers and retailer will know the equilibrium point and decide their product position from adjust b or θ again. Manufacturers or retailer may not want the game to go the equilibrium point that is the maximized channel profit point because that point may not the point that maximizes his or her profit. The results from adjust b or θ when the marketing environment changes by doing customer survey will guide the way to has better benefit in each point of product life. However, this finding can apply to decide how to coordinate a supply chain when both brands are owned by one company or even all of the players own by one company. The model proposed in this study only focused on the wholesale price contract. The future research should be developed using other types of contracts under different bargaining power scenarios. In addition, because our model is a deterministic model, the uncertainly of demand should also be explored in the future research.

In this study, the behavior of pricing under the level of product differentiation and bargaining power in three scenarios are discussed. The results show that when manufacturers have more bargaining power than the retailer the manufacturers can set wholesale prices at higher prices than when the retailer has more bargaining power. And the product differentiation affects both prices and quantities.

Although the exactly demand model of the second-generation antihistamine drug are not known, this section only gives an example to apply our price sensitive linear demand model in order to see the competing trend in different bargaining power scenarios for strategy choosing by using the data that can found in general public documents. In fact, the prescription drug market has unique characteristics such as there is no exact substitute for medicine being sold; there is a guarantee via patent protection; the insurance market affects the supply and demand. To get more closely coefficients, more research need to find how to get more accuracy the competition intensity of pricing degree of those unique characteristics. In this example, the manufacturers cost are none zero values, therefore instead of charging the same price of substitute product, both of the manufacturers and retailer charge different price to manipulate the product demand to maximized own profit. The results show that with the difference of the competition intensity of pricing degree, the pricing trends of those products are different. Understanding behavior of an oligopoly competition under different bargaining power scenarios is extremely important to set business strategy. This model can be extremely useful in real life business application. However, for applying our research in any business, the characteristics of products have to be not different much from our model and the accuracy coefficient which represent the competition intensity of pricing degrees are needed. Therefore, extensive empirical data should be collected in order to test the model repeatedly, and method to get parameter value should also be done.

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