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A Dynamic Pricing Method for Goods in Competitive Ecommerce Market

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Abstract

Dynamic pricing becomes one of the most attractive research topics in the field of ecommerce. In this paper, a novel dynamic pricing model composed retailer's current profit and its further development is presented. The core of the model is online customer perceived value, and based on which the optimal price equilibrium is provided. To make goods competitive, we adjust function weight by customer lifetime profit forecast and define goods price upper limit by contrasting goods utilities. An example analysis is done to prove that the pricing model is feasible. The paper gives a pricing method workflow to the online enterprises as a pricing practice direction.

Keywords: *dynamic pricing, ecommerce, customer perceived value, competitive*

1. Introduction

Dynamic pricing in ecommerce is a dynamic adjustment of the product or service price by searching and analyzing online customer purchase behavior. With the advent of e-commerce, how an online enterprise can achieve profit maximum and strong his competitiveness through dynamic pricing decision becomes a problem urgent to be settled.

Dynamic pricing method is developed very rapidly in recent years. Ding Tongqing[1] studied an optimal pricing model for perishable commodities and its particle swarm optimization solution. Cheng Yan [2] researched a decision optimization problem of dynamic pricing for product line in e-retailing setting. Wei Zhonglong [3] developed a dynamic pricing strategy based on customer perceived value analysis. Zhou Wenan [4] proposed a new profit oriented dynamic pricing mechanism and set a pricing model based on optimum price in competitive environment .Most of these papers tended to take the seller current profit as the only objective or analyzed customer perceived value only in traditional company environment.

Based on all above studies, this paper develops a novel model for dynamic pricing strategy of web-retails, which has the advantage of comprehensive advisement and practical method. Firstly, we employ conjoint analysis to detect weight of customer perceived value factors of electronic environment, especially the relationship between price and customer perceived value. Secondly, we propose a dual-objective pricing model and derive the price equilibrium P. Thirdly, we set different parameter in the model for different appreciation-potential customers to maximize customer lifetime profit for electronic retailers and have an example analysis.

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2. Customer Perceived Value of Electronic Commerce

2.1. Definition of Online Customer Perceived Value

Zeithaml's theory [5] about customer perceived value's definition and factors is widely accepted by majority among various viewpoints. E-commerce customer perceived value is the customer's overall assessments of a product utility based on perceptions of what is received(such as quality and property) and what is given(such as price) in the process of online shopping.

2.2. Factors Determination of Online Customer Perceived Value

The factors influencing online customer perceived value come from both product itself and online shop. Same goods with different service often have different perceived value. Based on the prior literatures [6-7], we select three categories of key factors directly related to consumers' interactions with online businesses: functional factor, procedural factor, social factor. The functional factor deals with aspects of price advantage, product quality, distribution method, personalized service. The procedural factor includes the aspects of network interaction, network security, privacy protection, operation simplicity. The social factor pertains to e-shop credit and relationship value.

3. Analyzing Customer Perceived Value Using Conjoint Analysis

Conjoint analysis is first proposed by Luce and Tukey in1964, and first used to calculate consumer preference in marketing field in 70's. It consists of generating and conducting specific experiments among customers with the purpose of modeling their purchasing decision. The work-flow is as follows. Firstly, we simulate an actual product by supposing it have certain attributes and present many product concepts which is composed of different product attribute levels as keywords in columns to responder. Secondly, each responder is asked to look through all the concepts cards and grade them according to their personal purchasing preferences. Consumer preferences are modeled by using mathematic statistics analysis. At last, the importance of every attributer and the utility of every attribute level will be calculated, and then customer perceived value is revealed.

In this article, we apply full-concept approach to compose product concepts, and use orthogonal design method to reduce the number of bundle of attribute levels, and model preferences by using utility function forms which named part-worth model.

3.1. Product Concept and Attribute Level Utility

The function of global customer perceived value is in (1).

$$V(x)=\sum_{i=1}^{n}\sum_{j=1}^{m} v_{ij} \bullet x_{ij} \ . \qquad (1)$$

V(x): global customer perceived value;

n :number of attributes(factors);

m: number of attribute(factor) levels of every attribute;

v_{ij}: utility of level j of attribute i;

x_{ij}: if level j of attribute i appear in the product concept , x_{ij} =1,else x_{ij} =0.

We can calculate utility of level *j* of attribute *i* by regression model.

3.2. Weight of Product Attributes

Based on the utility attached to product attributes' single performance levels the global utility (relative importance compared to other attributes) of every attribute can be calculated. The ratio of particular attribute's utility to the sum of all the attributes' utility is used to reveal the global utility of a particular attribute by (2) below:

$$Wi = Ci / \sum_{i=1}^{n} Ci \quad (2)$$

C_i: Max*(vij)*— Min(*vij*);

W_i : relative importance of attribute *i*;

Max(v_{ij}) :the minimal utility of all levels of the attribute *i*;

Min(v_{ij}) :the maximal utility of all levels of the attribute *i.*

4. Relationship Between Price and Customer Perceived Value

4.1. Customers Segmentation Based on Cluster Analysis

Conjoint analyzing on preference of customer entirety is non-significant for price discrimination. The significance is greatly improved only when customer markets are segmented by clustering analysis according to customer preference. Customers segmentation based on cluster analysis is considered to be the application of customer relationship management to dynamic pricing.

We assume that there are M concepts in a concept card and set n respondents as n samples of M dimensions. The dependent variable is the customer's preference grade given to M concepts in a concept card describing the sample (respondent). We assess similarity of every two samples based on measuring the Euclidean distance of them. We find and merge the two classes which have highest similarity into one class by setting and updating similarity matrix gradually until group all the samples into one class. We make the tree spectrum by the whole process of cluster analysis .Based on that, we group the samples into classes so that samples within a cluster have high similarity in comparison to one another, but are very dissimilar to samples in other clusters.

4.2. Relationship Between Price and Customer Perceived Value Based on Conjoint Analysis

Applying conjoint analysis to discover relationship between price and price utility is already supposed in some literatures [3]. It is a breakthrough of pricing method. But they summed product utilities without price utility and ignored the influence of customer perceived value to company profit. In order to make more practical application significance in pricing problem, this paper calculates a complete customer perceived value.

Conjoint analyzing customer perceived value for individual market segmentation, every utility of level j of attribute i in particular market segmentation is found. We assume that p_1, p_2, p_3 are levels of price attribute in one market segmentation and vp_1, vp_2, vp_3 are utility of the three levels. The relationship between price and price utility is shown in

Figure 1.

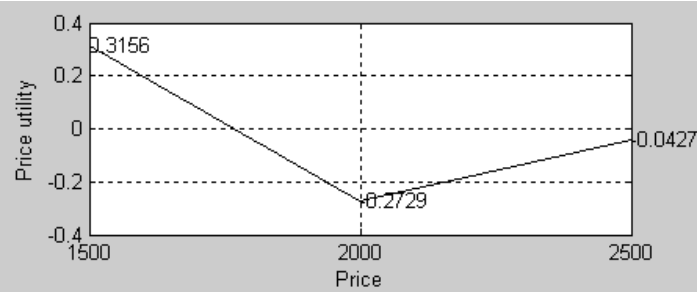

Figure 1. Relationship Between Price and Price Utility

Based on this, we can explore the relationship between price and price utility. The relationship is expressed by (3).

$$Vp = ((v_{p2} - v_{p1})/(p_2 - p_1)) \times (P - p_2) + v_{p2} \quad (3)$$

The price utility in various customer-segmentation is different, which reveals the different customer preference among various markets and furnishes the basis for dynamic pricing decision.

If we modify (1), we will get (4).

$$V = \sum_{i=1}^{n-1} \sum_{j=1}^{m} v_{ij} \bullet x_{ij} + V_p. \quad (4)$$

We substitute (3) for V_p of (4), and then we achieve (5).

So we find relationship between price and global customer perceived value.

$$V = \sum_{i=1}^{n-1} \sum_{j=1}^{m} v_{ij} \bullet x_{ij} + ((v_{p2} - v_{p1})/(p_2 - p_1)) \times (P - p_2) + v_{p2}. \quad (5)$$

The equation of global customer perceived value with price has the advantage of universality and accuracy. Equation (5) will be used to adjust own product price on the basis of calculating rival product utility. Furthermore, customer satisfaction function and company profit function both need the equation. Only in this way can we find the price equilibrium.

5. Establish Dual-Objective Pricing Model

5.1. Establish Simple-Objective Pricing Model for New Product

The method setting price in some paper [3] is customer satisfaction centered only and ignores company profit. It is defect in practical application because the ultimate goal of company is profit. So we set up a company profit function based on customer perceived value.

Assume that F is profit of product, G is sales amount, and C is cost of product. The company's profit function of online product is expressed as (6).

$$F = G \times (P - C) \quad (6)$$

The sales amount G is increasing function of perceived value V. The higher the perceived value of online product is, the larger the sales amount is. G function is showed as (7).

$$G=a \times V/(\sum_{k=1}^{K} V'(k)+V). \quad (7)$$

a: the market share of the particular preference segmentation. We divide customer segmentations by cluster analysis and questionnaire, and then extract customer individuality of various segmentations. Based on which, we distinguish customers of real market and achieve *a*.

K: the number of rival e-shops which sell same kind products.

V'(*k*):the customer perceived value of rival product. It can be expressed by (8).

$$V'(k)=\sum_{i=1}^{n-1}\sum_{j=1}^{m} v_{ij} \bullet x_{ij}' + ((v_{p2}-v_{p1})/(p_2-p_1)) \times (P'(k)-p_2)+v_{p2}. \quad (8)$$

x_{ij}': if level *j* of attribute *i* appear in the rival product concept , x_{ij} =1,else x_{ij} =0.

$V/(\sum_{k=1}^{K} V'(k)+V)$: the purchasing ratio of the particular preference segmentation.

Based on (6)(7)(8), we will achieve (9).It is the profit function which reveals the relationship between profit *F* and price *P*..

$$F=a \times (\sum_{i=1}^{n-1}\sum_{j=1}^{m} v_{ij} \bullet x_{ij} + ((v_{p2}-v_{p1})/(p_2-p_1) \times (P-p_2)+vp_2)/(\sum_{k=1}^{K} (\sum_{i=1}^{n-1}\sum_{j=1}^{m} v_{ij} \bullet x_{ij}'$$

$$+((v_{p2}-v_{p1})/(p_2-p_1)) \times (P'(k)-p_2)+v_{p2})+ (\sum_{i=1}^{n-1}\sum_{j=1}^{m} v_{ij} \bullet x_{ij} + ((v_{p2}-v_{p1})/(p_2-p_1) \quad (9)$$

$$\times (P-p_2)+v_{p2})) \times (P-C).$$

For the purpose of online retailers' benefit, we set product price lower limit as cost price *C* of product. $p \geq p=C$

5.2. Establish Dual-Objective Pricing Model for Product on Sale

5.2.1. Customer Satisfaction Function

Long-term and stable relationship between customers and retailers is crucial to the development of the latter. It is important strategy to pursue company's profit with enhancing customer satisfaction by improving the customer perceived value. According to the prior literatures [7][8], customer perceived value is the driving factor of customer-satisfaction and customer satisfaction *S*(*V*) is the linear increasing function of customer perceived value *V*. Assume that $S(V)= s \times V+ r$.

5.2.2. Dual-Objective Pricing Model:

We establish a dual-objective pricing model in which retailer current profit and customer satisfaction are both considered. It is showed as (10) which express the relationship of price P and max Π.

$$\text{Max } \Pi=\{a\times(\sum_{i=1}^{n-1}\sum_{j=1}^{m} v_{ij}x_{ij}+ (v_{p2}- v_{p1})/(p_2- p_1)\times(P- p_2)+v_{p2}) /(\sum_{k=1}^{K} (\sum_{i=1}^{n-1}\sum_{j=1}^{m} v_{ij}\bullet x_{ij}' +((v_{p2} - v_{p1})/(p_2- p_1))\times(P'(k) - p_2) +v_{p2})+ (\sum_{i=1}^{n-1}\sum_{j=1}^{m} v_{ij}\bullet x_{ij} + ((v_{p2}- v_{p1})/(p_2- p_1)\times(P- p_2) +v_{p2}))\times((1-\beta)\times(P- C) +\beta\times s\times (\sum_{i=1}^{n-1}\sum_{j=1}^{m} v_{ij}x_{ij}+((v_{p2}- v_{p1})/(p_2- p_1))\times(P- p_2)+v_{p2})+r). \quad (10)$$

β is the parameter that represents weight of customer satisfaction, and 1-β is the weight parameter of retailer current profit F. The parameters are determined by the online retailers' company location strategy, current marketing strategy and customer relationship strategy.

Based on (10), we can get the price equilibrium P which makes customer lifetime value to maximum.

$$P=(C-(1+\beta)\times(\sum_{i=1}^{n-1}\sum_{j=1}^{m} v_{ij}\bullet x_{ij} +v_{p2} - (v_{p2} - v_{p1})\times p_2 / (p_2- p_1))\times(p_2- p_1)/(v_{p2}-v_{p1})-\beta\times C)/2. \quad (11)$$

5.3. Adjust Parameter β Value Based on Customer Lifetime Value Analysis

To avoid allocating sales resource to all customers indiscriminately and inefficiently, we need a further market subdivision on the basis of customer lifetime profit (CLV) analysis. Various markets should be set different β in the model.

5.3.1. Customer Lifetime Value Analysis: CLV is the profit value which company derived from customer in their whole lifetime. Some scholars had succeeded in considering two factors: customer current value (CCV) and customer potential value [9].

Customer current value (CCV) is the profit value sum which customer is expected to create for sellers during the entire process of customer lifetime on the assumption that current customer purchase patterns remain unchanged. Based on this definition, we can calculate CCV by multiplying customer profit of the last month and the expected customer life cycle time. The formula is expressed as (12).

$$CCV = \sum_{t=1}^{n} P0\,(1/\,(1+d))^{t} \quad (12)$$

$P0$ is customer profit of the last month; d is discount rate. For a product already on sale, we can calculate customer current value according to customer's transaction records.

Customer potential value is the profit value increment which customer is expected to create for sellers on assumption that companies change current customer purchase patterns better by adopting appropriate customer retention strategy. It is the primary basis of companies allocating sales resource decision to customers. After forecasting CLV by curve fitting method [10-11], we can calculate customer potential value based on the follow equation: Customer potential value=$CLV-CCV$.

5.3.2. Adjust Parameter β Value: Customers with different customer potential value and CCV should be allocated with different sales resource and different β value in the model.

The first type of customers brings companies negative profits and is the least attractive type. They have low CCV and low customer potential value .Because they are burden which retailer should encourage turn to competitor; we set lowest β in their pricing model. The second type of customers has low CCV but high customer potential value. These customers have big business volume but offer very small share to our retailer. So, retailer needs to pay more attention to establish stable relationship with them but not to obtain current value. In their model, β should be higher than 1− β . The third type of customers has high CCV and low customer potential value. Retailer has established stable relationship with it and can have a decent return from them. In their model, β should be set smaller than 1− β . The last type of customers with high CCV and high customer potential value offers whole share of their business to retailer and their business is growing rapidly. In order to retain these customers and derive sufficient profit, β basically equal to 1− β is set in their model.

5.4. Set Price Upper Limit in Competitive Markets

A product can be accepted by customers only when its customer perceived value is greater than zero. Based on relationship between v_p and p expressed by (5), we get one price upper limit $\overline{p}_1$ as (13).

$$P \leq \overline{p}_1 = p_2 - ((p_2 - p_1) / (v_{p2} - v_{p1})) \times (\sum_{i=1}^{n-1} \sum_{j=1}^{m} v_{ij} \bullet x_{ij} + v_{p2}). \quad (13)$$

On the other hand, we suppose that our retailer sell product type the same as rival and cost the same as rival. In the competitive environment, to improve the competitiveness of retailer, we demand our product's customer perceived value higher than rival's. That is $V>V'(K)$. Substitute (5) for V and substitute (8) for $V'(K)$, we achieve the other price upper limit $\overline{p}_2$ as (14).

$$P \leq \overline{p}_2 = (\sum_{i=1}^{n-1} \sum_{j=1}^{m} v_{ij} \bullet x_{ij}' - \sum_{i=1}^{n-1} \sum_{j=1}^{m} v_{ij} \bullet x_{ij}) \times ((p_2 - p_1) / (vp_2 - vp_1)) + P' . \quad (14)$$

We set price upper limit $\overline{p}$ =Min $\{\overline{p}_1, \overline{p}_2\}$ or $\overline{p}$ =Max $\{\overline{p}_1, \overline{p}_2\}$ in the model of different segmentations divided according to customer lifetime value analysis.

6. Example Analysis

In this paper, we take mobile phone in e-shop for example to do some experiment. According to theory in chapter "factors determination of online customer perceived value", we determine foremost six attributes and three attribute levels in each attribute: price (1500, 2000, 2500), brand(Apple, Nokia, Amoi), screen size (3.1-4.0, 4.1-4.9, 5.6-), Operating System(ANDROID, Symbian, Windows), e-shop reputation(three-crown, four-crown, five-crown), delivery(Yuantong, Yunda, SF). We reduce the number of bundle of attribute levels to nine by orthogonal design and collect responder data. The conjoint analysis program was written by SPSS software. The result of conjoint analysis of a particular segmentation market is enumerated in Table 1.

Table 1. Result of Conjoint Analysis

Attributes	Attribute levels	Segmentation market 1		Segmentation market 2	
		Utility	Weight	Utility	Weight
Price	1500	0.3156	16.16	0.2145	10.23
	2000	-0.2729		-0.0178	
	2500	-0.0427		-0.1967	
Brand	Apple	0.8233	31.78	0.3427	21.73
	Nokia	0.1320		0.1875	
	Amoi	-0.9553		-0.5302	
Screen size	3.1-4.0	-0.3821	11.26	-0.1735	8.16
	4.1-4.9	0.2480		0.1544	
	5.6-	0.1341		0.0191	
Operating system	ANDROID	0.7723	28.59	0.3758	22.66
	Symbian	-0.8277		-0.5345	
	Windows	0.0554		0.1587	
E-shop reputation	Three-crown	-0.3182	11.14	-0.5846	25.18
	Four-crown	0.0128		0.1574	
	Five-crown	0.3054		0.4272	
Delivery	Yuantong express	-0.1109	6.70	-0.1680	12.03
	Yunda express	-0.1319		-0.1475	
	SF express	0.2428		0.3155	
Pearson's R		0.924			
Pearson's $ Significance		0.000			

Now our retailer will sell a new mobile phone (Apple, 4.3, ANDROID, three-crown, SF Express) and the mobile phone's cost C=1000. In the rival e-shops, the present product (1398, Nokia, 4.3, Windows, five-crown, Yuantong) is on sale. Assume that the share value *a* in segmentation market 1 is 20000. When β =0.2, we obtain the price equilibrium P value is 1423, F=5361800, V=1.8382. When β =0.4, we obtain the price equilibrium P value is 1376, F=4812800, V=1.8935. When β =0.6, we obtain the price equilibrium P value is 1329. F=4277500, V=1.9488. We contrast the price and profits under different β , and then find that the more retailer pay attention to current profit, the higher they lay down the price and obtain the profits, but the lower the customer satisfaction is.

7. Conclusions

This paper took customer perceived value as the pricing core and researched the affection of a series of factors on online customer perceived value. Considering that customer perceived value determines not only current profit but also long-term profit of retailer, the paper set dual-objective pricing model which aimed at finding out optimal price equilibrium to maximize Π . Moreover, customer sectors with different estimate CLV were provided with different β and different price upper limit. The dynamic pricing workflow is shown in Figure 2. It gives the online enterprises a good direction in pricing practice.

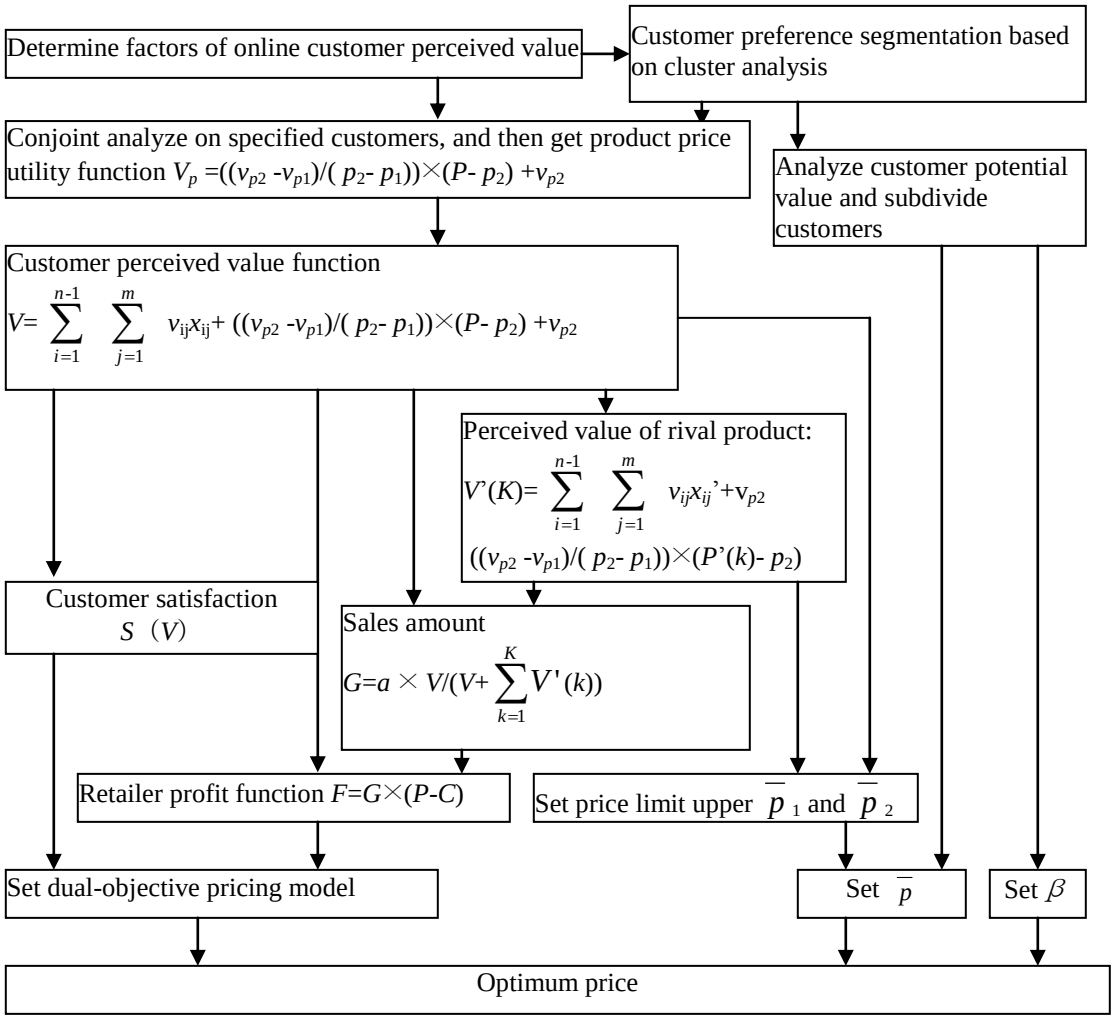

Figure 2. Price Model Establishment

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References

[1] D. Tongqing, T. Peng and T. Zhiyou, "Optimal Pricing Model for Perishable Commodities and its Particle Swarm Optimization Solution", Computer Engineering and Applications, **(2005)** April.
[2] C. Yan, "Research on Method of Dynamic Pricing for Product Line in E-commerce", Journal of Systems Engineering, vol. 25, no.4, **(2010)**.
[3] W. Zhonglong and G. Chen, "Research of Product Pricing Strategy Based on Customer Perceived Value Analysis", Management World, no. 4, **(2007)**.
[4] Z. Wenan, A. Xiaoli, X. Bing and S. Junde, "A Novel QoS and Profit Oriented Dynamic Pricing and Admission Control Mechanism", Proceedings of the 6TH WICOM, **(2010)** September 23-25; Sichuan, China.
[5] V. A. Zeithaml, "Consumer Perceptions of Price", Quality, and Value: A Means-end Model and Synthesis of Evidence, Journal of Marketing, vol. 52, **(1988)**.
[6] G. Haibo, "Research on Loyalty Formation Mechanism of the Business to Consumer E-Commerce for Domestic University Students", Ph.D Thesis of Shanghai JiaoTong University, **(2008)**.
[7] Y. Li and G. Changchun, "A Pricing Model of Faddish Product Based on Customer Perceived Value, Consumer Economics", vol. 27, no. 5, **(2011)**.
[8] M. Jeon, "Impact of Perceived Website Service Quality on Customer E-loyalty on A Lodging Website", Graduation Thesis and Dissertations, **(2009)**.
[9] Q. Zu, T. Wu and H. Wang, "A Multi-factor Customer Classification Evaluation Model", Computing and Informatics, vol. 29, **(2010**).
[10] X. Cheng and H. Zhang, "A Hybrid Model for Customer Value Assessment from CLV Perspective", Journal of Computational Information Systems, vol. 8, no. 17, **(2012)**.
[11] S. Shulei, L. Xiaowei, M. Xiuli and W. Haiyan, "Decision Model and Pricing Strategies for Customer Retention Based on Customer Identification", Chinese Journal of Management, vol. 8, no. 10, **(2011)**.
[12] G. Perakis and A. Sood, "Competitive Multi-period Pricing for Perishable Products", A Robust Optimization Approach Mathematical Programming, Series A and B.107, vol. 1 ,**(2006)**.
[13] X. Zhong-kai, L. Hao, P. Zhi-qiang, "Optimal Dynamic Pricing for Seasonal Goods in Competitive Markets with Internet", Systems Engineering-Theory&Practice, vol. 30, no. 2, **(2010)**.
[14] C. Currie, R. Cheng and H. Smith, "Dynamic pricing of airline tickets with competition", Journal of the Operational Research Society, vol. 59, no. 8, **(2008)**.

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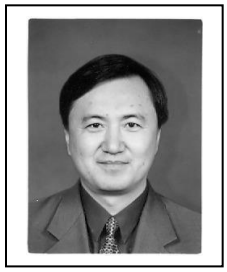

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