

# Pricing Strategy of Software Products Based on Cloud Accounting Resource Sharing Platform

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## ABSTRACT

Cloud accounting resource sharing platform as a third-party platform for communication and transaction between suppliers and consumers. Under the new platform environment, it is very important to determine the pricing strategy of suppliers and analyze the choice of consumers. Based on this background, an evolutionary game model is constructed in which suppliers adopt high or low price pricing strategy and consumers choose customized or non-customized software products, and the game results are classified and analyzed. The conclusion is summarized as two points. The choice of suppliers pricing strategy is closely related to the difference between high and low prices of software pricing and the demand of software products, and the choice of customers is affected by the loss utility of using non-customized products.

**Keywords:** *Game theory, cloud accounting, resource sharing, pricing strategy*

## 1. INTRODUCTION

The cloud accounting resource sharing platform not only provides a place for suppliers to display and sell products, but also provides a safe consumption environment for consumers [1]. Ojala. A proposes two pricing methods that are mainly used by suppliers under the SaaS service model, namely, regular fixed payment and pay-per-use [2]. Zhou et al. point out that the purchasing power of consumers in the market is different, and the differentiation of products quality can meet the needs of different consumption so as to attract more consumer groups [3]. Zhang proposes the strategy of using lower price to occupy the consumer market firstly and then providing high-quality service to build reputation and brand to consolidate consumer groups [4]. Zeng and Shao report that the cost of customized products includes not only universal fixed cost but also marginal cost of customization [5]. Radhi and Zhang assert that the behavior of suppliers is the main factor affecting products pricing [6]. Under the new information model of the Internet, consumers can choose different service models according to their own needs. Most small and medium-sized consumers choose the software-as-a-service model (SaaS), that is to order application service on software platform individually. So based on this background, this article discusses which pricing strategy suppliers should formulate and how consumers choose software products.

## 2. PROBLEM DESCRIPTION AND MODEL CONSTRUCTION

### 2.1. Problem Description and Assumptions

The price strategy adopted by the suppliers after entering the resource sharing platform directly affects the success of suppliers' in opening up a new sales channel. Suppliers can choose to provide a high-priced and high-value service or choose to attract a large number of consumer groups with low-price strategy. Customers can directly choose to use non-customized software products, which is no different from software products obtained from traditional sales channels or choose to use customized software products. The software transaction method in the cloud accounting resource sharing platform discussed in this article is based on the SaaS model, and a self-constructed game model is used to play a game between the choice of consumers and the pricing strategy of suppliers, as shown in Table 1. The specific assumptions are as follows:

1.  $P$  is the unit price paid for using the software products.  $P_h$  is a high price per unit of software products,  $P_l$  is the low price per unit of software products,  $P_h > P_l$ .
2.  $\theta_h$  is the high price marginal additional unit price,  $\theta_l$  is the low price marginal additional unit price,  $\theta_h > \theta_l$ .
3.  $Q$  is the market demand for the software products. Assuming that software products bring considerable utility to the consumers, the customers will definitely use the software products [7].  $Q_h$  is the demand for products when suppliers adopt the high-price strategy,  $Q_l$  is the demand for products when suppliers adopt the low-price strategy.

Assuming that all consumers in the market are price sensitive customers, suppliers will attract more customers if they adopt the low price strategy,  $Q_l > Q_h$ .

4.  $F$  is the fixed cost of the suppliers developing the software products.

5.  $W$  is the marginal cost incurred by the suppliers' customization of personalized functions.

6.  $R$  is the unit revenue brought by the consumers using software products.  $R_Y$  is the unit revenue brought by using customized software products,  $R_N$  is the unit benefit brought by using non-customized software products.

7.  $C$  is the loss caused by the use of non-customized software products by the consumers.

8. The probability that the suppliers implement the high price strategy is  $x(0 < x < 1)$  and the probability of implementing the low-price strategy is  $1-x$ . The probability that consumers choose to use customized software products is  $y(0 < y < 1)$  and the probability of using non-customized software products is  $1-y$ .

### 2.2. Model Construction

Expected benefits when suppliers implement the high-price strategy:

$$U_{sh} = y[(P_h + \theta_h)Q_h - F - W] + (1-y)(P_h Q_h - F) \quad (1)$$

Expected benefits when suppliers implement the low-price strategy:

$$U_{sl} = y[(P_l + \theta_l)Q_l - F - W] + (1-y)(P_l Q_l - F) \quad (2)$$

Average revenue of suppliers:

$$\bar{U}_s = xU_{sh} + (1-x)U_{sl} \quad (3)$$

Substituting equations (1) and (2) into equation (3), according to the Malthusian equation[8], the dynamic equation of replication of suppliers adopting high price strategy :

$$X = \frac{dx}{dt} = x(U_{sh} - \bar{U}_s) = x(1-x)[P_h Q_h - P_l Q_l + (\theta_h Q_h - \theta_l Q_l)y] \quad (4)$$

Suppliers choose to use customized software products to replicate dynamic equation:

$$Y = \frac{dy}{dt} = y(U_{sl} - \bar{U}_e) = y(1-y)[(R_Y - R_N)Q_l + C + (Q_h - Q_l)(R_Y - R_N)x] \quad (5)$$

**Table 1** Game matrix of software products pricing under the cloud accounting resource sharing platform

Supplier s	Customers	
	Customized y	Non-customized 1-y
High price x	$(P_h + \theta_h)Q_h - F - W$ , $(R_Y - P_h - \theta_h)Q_h$	$P_h Q_h - F$ , $(R_N - P_h)Q_h - C$
Low price 1-x	$(P_l + \theta_l)Q_l - F - W$ , $(R_Y - P_l - \theta_l)Q_l$	$P_l Q_l - F$ , $(R_N - P_l)Q_l - C$

Combine formulas (4) and (5) to calculate a two-dimensional dynamic system:

$$\begin{cases} dx/dt = x(1-x)[P_h Q_h - P_l Q_l + (\theta_h Q_h - \theta_l Q_l)y] \\ dy/dt = y(1-y)[(R_Y - R_N)Q_l + C + (Q_h - Q_l)(R_Y - R_N)x] \end{cases} \quad (6)$$

Assuming  $dx/dt = 0$ ,  $dy/dt = 0$ , the equilibrium points of system (1) can be obtained. The five Nash equilibrium points of suppliers and customers dynamic evolution game system are:

$$\begin{aligned} & A(0,0) \quad , \quad B(0,1) \quad , \quad C(1,0) \quad , \quad D(1,1) \quad , \\ & E\left(\frac{(R_N - R_Y)Q_l - C}{(Q_h - Q_l)(R_Y - R_N)}, \frac{P_l Q_l - P_h Q_h}{\theta_h Q_h - \theta_l Q_l}\right), X_D = \frac{(R_N - R_Y)Q_l - C}{(Q_h - Q_l)(R_Y - R_N)}, \\ & Y_D = \frac{P_l Q_l - P_h Q_h}{\theta_h Q_h - \theta_l Q_l}, E(X_D, Y_D). \end{aligned}$$

### 3. EVOLUTIONARY GAME ANALYSIS

#### 3.1. Stability Analysis of Equilibrium

Construct a Jacobian matrix to analyze the stability of the balance points obtained[9], and test whether they conform to the evolutionary stability strategy(ESS). Calculate the partial derivatives of  $x$  and  $y$  for equations (4) and (5) respectively, and obtain the Jacobian matrix:

$$J = \begin{bmatrix} \frac{\partial X}{\partial x} & \frac{\partial X}{\partial y} \\ \frac{\partial Y}{\partial x} & \frac{\partial Y}{\partial y} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad (7)$$

$$a_{11} = (1-2x)[P_h Q_h - P_l Q_l + (\theta_h Q_h - \theta_l Q_l)y]$$

$$a_{12} = x(1-x)(\theta_h Q_h - \theta_l Q_l)$$

$$a_{21} = y(1-y)(Q_h - Q_l)(R_Y - R_N)$$

$a_{22} = (1-2y)[(R_Y - R_N)Q_l + C + (Q_h - Q_l)(R_Y - R_N)x]$  If the following conditions are met:

- $a_{11} + a_{22} < 0$  (trJ);
- $\begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} = a_{11}a_{22} - a_{12}a_{21} > 0$  (detJ).

Then the equilibrium point of the replication dynamic equation is (asymptotically) locally stable[10], the balance point is the evolutionary stability strategy(ESS).

- $W_p = P_h Q_h - P_l Q_l$ ,  $W_\theta = \theta_h Q_h - \theta_l Q_l$
- Proposition 1
- $W_p > 0$ ,  $W_\theta < 0$ ,  $|W_\theta| < |W_p|$ ,  $(R_N - R_Y)Q_h > C > (R_N - R_Y)Q_l$ , the system (1) is stable at ({high price, non-customized}).
  - $W_p > 0$ ,  $W_\theta < 0$ ,  $|W_\theta| < |W_p|$ ,  $C > (R_N - R_Y)Q_h$ , the system (1) is stable at ({high price, customized}).
  - $W_p > 0$ ,  $W_\theta < 0$ ,  $|W_\theta| > |W_p|$ ,  $C > (R_N - R_Y)Q_h$ , the system (1) is stable at ({low price, customized}).
  - $W_p > 0$ ,  $W_\theta < 0$ ,  $|W_\theta| > |W_p|$ ,  $(R_N - R_Y)Q_h > C > (R_N - R_Y)Q_l$ , the system (1) is stable at ({low price, customized}) and ({high price, non-customized}).
  - $W_p > 0$ ,  $W_\theta < 0$ ,  $(R_N - R_Y)Q_l > C$ , the system (1) is stable at ({high price, non-customized}).

Proof: According to the two conditions of the Jacobian matrix, the equilibrium points in the above propositions are tested for local stability. The test results are shown in Table 2 to Table 6.

**Table 2** Case (1) stability analysis

Balance point	trJ	detJ	Local stability
(0,0)	+	+	Unstable
(0,1)		-	Saddle point
(1,0)	-	+	ESS
(1,1)		-	Saddle point

**Table 3** Case (2) stability analysis

Balance point	trJ	detJ	Local stability
(0,0)	+	+	Unstable
(0,1)		-	Saddle point
(1,0)		-	Saddle point
(1,1)	-	+	ESS

**Table 4** Case (3) stability analysis

Balance point	trJ	detJ	Local stability
(0,0)	+	+	Unstable
(0,1)	-	+	ESS
(1,0)		-	Saddle point
(1,1)		-	Saddle point

**Table 5** Case (4) stability analysis

Balance point	trJ	detJ	Local stability
(0,0)	+	+	Unstable
(0,1)	-	+	ESS
(1,0)	-	+	ESS
(1,1)	+	+	Unstable
( $X_D, Y_D$ )		-	Saddle point

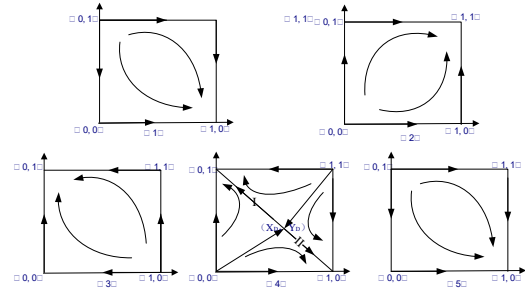
**Table 6** Case (5) stability analysis

Balance point	trJ	detJ	Local stability
(0,0)		-	Saddle point
(0,1)	(+)	- (+)	Saddle point(ESS)
(1,0)	-	+	ESS
(1,1)	+ (-)	+ (-)	Unstable(Saddle point)

### 3.2. Evolutionary Result Analysis

According to the stability analysis of the above five situations, the evolutionary game process between the suppliers and the customers in each situation can be

obtained. The evolution phase diagrams corresponding to the above five situations are shown in Figure 1.



**Figure 1** Evolutionary dynamic phase diagram

According to the dynamic evolution phase diagram of the above system (1), the analyses are as follows:

Suppose that when suppliers implement the low-price strategy, customers have more demand for software products than when the high-price strategy is implemented,

$$Q_l > Q_h \cdot \frac{Q_l}{Q_h} = \beta, \beta (\beta > 1).$$

1. From the perspective of suppliers, the total revenue generated by the software demand when suppliers adopt the low-price strategy is lower than the total revenue when the high-price strategy is adopted, and suppliers tend to adopt the high-price strategy at this time. For customers, when the utility loss caused by using non-customized software products is greater than the income difference between high and low prices when demand for the low-price, but less than the income difference between high and low prices when the demand for the high-price, customers tend to choose non-customized software products.
2. From the perspective of suppliers, the total revenue generated by the software demand when suppliers adopt the low-price strategy is lower than the total revenue when the high-price strategy is adopted. So suppliers tend to adopt the high-price strategy. For customers, the utility loss caused by using non-customized software products is not only greater than the income difference between high and low prices when demand for the low-price, but also greater than the income difference between high and low prices when demand for the high-price, customers tend to choose customized software products.
3. From the perspective of suppliers, the total revenue generated by the software demand when suppliers adopt the low-price strategy exceeds the total revenue when the high-price strategy is adopted. At this time, suppliers tend to implement the low-price strategy. For customers, the utility loss caused by using non-customized software products is not only greater than the income difference between high and low prices when demand for the low-price, but also greater than the income difference between high and low prices when demand for the high-price, customers tend to choose customized software products.
4. The equilibrium of the system to (0,0) or (1,1) is related to the evolutionary game matrix and the initial state of the

system. The broken line connecting the two unbalanced points and passing through the saddle point can be used to judge the convergence of the system.

5. From the perspective of the customers, the utility loss caused by using non-customized software products is not only lower than the income difference between high and low prices when demand for the low-price, but also lower than the income difference between the high and low prices when the demand for the high-price, customers tend to choose non-customized software products. In this case, regardless of whether the total revenue generated by the software demand when suppliers adopt the low-price strategy is lower or higher than the total revenue brought by the high-price strategy, the stability point of the system will not change, the high price strategy will always be implemented by suppliers.

### 3.3. Analysis of the Influence of Parameter Changes on the Fourth Situation

There are two situations for the balance of the fourth hypothesis. To determine which situation the system (I) converges to is determined by the size of the area  $S_1$  of region I and area  $S_2$  of region II. The calculation results are as follows:

$$S_1 = \frac{1}{2} \left( \frac{(R_N - R_Y)Q_l - C}{(Q_h - Q_l)(R_Y - R_N)} + \frac{(\theta_h + P_h)Q_h - (\theta_l + P_l)Q_l}{\theta_h Q_h - \theta_l Q_l} \right) \quad (8)$$

It can be seen from formula (8) that the parameters affecting area (I) include  $R_N, R_Y, P_h, P_l, Q_h, Q_l, \theta_h, \theta_l, C$ .

Proposition 2 The higher the unit revenue that customers can obtain from using customized software products, and the lower the unit revenue generated by using non-customized software products, the greater the probability that suppliers will implement the low-price strategy and customers will choose customized software products. The opposite is the same.

Proof: The derivative of  $S_1$  to  $R_N$  and  $R_Y$  respectively,

$$\frac{\partial S_1}{\partial R_N} = \frac{1}{2} \left( \frac{C(Q_l - Q_h)}{(Q_h - Q_l)^2 (R_Y - R_N)^2} \right) < 0$$

$$\frac{\partial S_1}{\partial R_Y} = \frac{1}{2} \left( \frac{C(Q_h - Q_l)}{(Q_h - Q_l)^2 (R_Y - R_N)^2} \right) > 0$$

so  $S_1$  is a decreasing function of  $R_N$  and an increasing function of  $R_Y$ .

Proposition 3 When suppliers adopt the high price strategy, the customers have a higher probability of choosing non-customized software products; When suppliers adopt the low price strategy, the customers have a higher probability of choosing customized software products.

Proof: The derivative of  $S_1$  to  $P_h, Q_h, P_l$  and  $Q_l$  respectively,

$$\frac{\partial S_1}{\partial P_h} = \frac{1}{2} \frac{Q_h(\theta_h Q_h - \theta_l Q_l)}{(\theta_l Q_l - \theta_h Q_h)^2} < 0, \quad \frac{\partial S_1}{\partial \theta_h} = \frac{1}{2} \frac{(P_l Q_l - P_h Q_h) Q_h}{(\theta_l Q_l - \theta_h Q_h)^2} < 0$$

$$\frac{\partial S_1}{\partial P_l} = -\frac{1}{2} \frac{Q_l(\theta_h Q_h - \theta_l Q_l)}{(\theta_l Q_l - \theta_h Q_h)^2} > 0$$

$$\frac{\partial S_1}{\partial \theta_l} = -\frac{1}{2} \frac{Q_l(P_l Q_l - P_h Q_h)}{(\theta_h Q_h - \theta_l Q_l)^2} > 0$$

so  $S_1$  is a decreasing function of  $P_h$  and  $Q_h$ .  $S_1$  is an increasing function of  $P_l$  and  $\theta_l$ .

Proposition 4 The greater the loss utility of the customers that use non-customized software products, the greater the probability that the customers will choose high-priced customized products. The opposite is the same.

Proof: The derivative of  $S_1$  to  $C$ ,

$$\frac{\partial S_1}{\partial C} = -\frac{1}{2} \frac{1}{(Q_h - Q_l)(R_Y - R_N)} > 0$$

so  $S_1$  is a decreasing function of  $C$ .

## 4. CONCLUSION

The strategic choice between the suppliers and the customers is related to the software price difference, the ratio of product demand, and the loss utility of using non-customized software products. The pricing strategy of suppliers is mainly affected by the difference between high and low prices. At the same time, when considering the system balance point, it will also be affected by the corporate strategy of customers. The strategic choice of customers is mainly affected by the loss of utility of using non-customized software products. Compared with previous articles or other articles that analyze the pricing strategy of platform software products, this article is not only limited to discussing the impact of a single influencing factor on supplier pricing strategies and consumer choices, but also focusing on the relationship between the influencing factors and the impact of this relationship on the game results.

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