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Profits Optimization in the Supply Chain of Online Game Industry

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Abstract: Online game is a typical E-business indusry. Firstly, the problem is pointed out that the present researches on supply chain contracts designed for tangible traditional products have not considered the characteristic of intangible products such as online game industry. Secondly, the members and operation progress of the supply chain are explored in online game industry. Thirdly, a new supply chain contract model is provided for online game industry under the reference to the existed contracts models. At last, a mathematical example is provided, the profits for the whole supply chain and the profits for every member have been compared with between in the new contract model and in the old contract model, and the results shows the new contract model is better.

Key ward: profits optimization, supply chain, contract, online game industry

1. INTRODUCTION

Online game is a typical E-business indusry. It is also an emerging entertainment software industry. It is successful and fast growing. The online game market is expected to reach $4.4 billion by 2010 according to data released by Parks Associates.In addition to traditional game industry companies like publishers, hardware and console manufacturers, the research included other sources new to the gaming sector including portals like Yahoo, Real Networks and AOL; and NHN Corporation, which operates an online gaming site in Korea and recently opened U.S. operations. Those companies are going to help the market grow, along with dominant players like Microsoft, EA, and other traditional industry companies. Supporting these revenues are PC gamers who spend an average of 18.5 hours per week playing games, and 70 percent of PC gamers take part in multiplayer mode online. In comparison, console gamers play an average 13.6 hours per week, portable games are played 8.9 hours on average, and mobile games about 4.6 hours.

The supply chain of online game industry is made up of game developer, operational company, retailer and online game player. Optimal supply chain performance requires the execution of a precise set of actions. Unfortunately, those actions are not always in the best interest of the members in the supply chain, i.e., the supply chain members are primarily concerned with optimizing their own objectives, and that self-serving focus often results in poor performance. So supply chain is a typical system that needs to be coordinated. All the trade-offs among the firms in supply chain are fulfilled by contracts, so all the means that help to achieve coordination will be restricted by contracts. The supply chain contracts are one of the most important problems in supplying management as the foundation to coordinate supply chain.

2. LITERATURES REVIEW

The academia has investigated supply chain contracts including quantity discount[1-5], return[6], quantity flexibility[7], backup agreements[8], option[9], channel rebate[10] and revenue sharing[11-12]. The models used in these contracts include EOQ, newsboy problem, Nash equilibrium, stackelberg equilibrium. The typical literatures on supply chain contracts have been listed in Table 1.

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Table 1. Typical literatures on supply chain contracts

Type of contract	Typical literatures
Quantity discount	Crowther (1964); Monahan（1984）; Lee and Rosenblatt（1986）; Jolekar（1988）; Lal and Staelin(1984); Deezner and Wesolowsky（1989）; Dada and Srikanth（1987）; Kohli and Park（1989）; Weng and Wong（1993）; Weng（1995）
Return	Pasternack（1985）; Emmons and Gilbert（1998）; Tsan-Ming Choi,Duan Li and Houmin Yan(2004)
Backup agreements	Gary.D.Eppen and Ananth.V.Iyer（1997）
Quantity flexibility	Tsay（1999）; Jianghua Wu（2005）
Option	Dawn Barnes-Schuster,Yehuda Bassok and Ravi Anupindi(2002); Zhiping Chang and Fu Jiang（2004）; Shihua Ma，Jianyang Hu and Yong Lin（2004）
Channel rebates	Terry.A.Taylor（2002）
Revenue sharing	Cachon and Lariviere（2000）; Yigal Gerchak and Yunzeng Wang (2004); Ilaria Giannoccaro and Pierpaolo Pontrandolfo (2004)

However, the existed supply chain contracts are mainly designed for traditional and tangible products without thinking about the characteristics of digital products such as online game. The rapid development in online game industry provides us a challenge to research. The profits models for traditional and tangible products mainly think about the marginal manufacturing cost, purchasing cost, transportation cost, storage cost and so on. Furthermore, the marginal manufacturing cost percent in retail price is very high. The costs of online game products are mainly research and development costs, and the costs are very large. Once research and development succeeds, the marginal manufacturing cost will be very small, and the marginal manufacturing cost percent in retail price is very little. As regards storage and transportation, thinking about the very little volume and weight, the storage cost and transportation cost are very little. All the difference between traditional tangible products and digital intangible products such as online game causes the different profits models.

3. MODELS

3.1 Notes

c: the cost of developing online game software;

c_1: agent cost operational company offered to develop company

c_2: marginal manufacturing cost for each online game card in operational company

c_3: the license fee retailer offered to operational company in the new contract

c_4: the marginal retail cost of retailer

c_5: the fixed cost of retailer

c_6: the fixed cost in operational company

ω_0: the wholesale price of each online game card operational company selling to retailer in the old contract

ω: the wholesale price of each online game card operational company selling to retailer in the new contract

Φ_1: the revenue proportion retailer shared, and $(1-\Phi 1)$ is offered to operational company in the new contract

Φ_2: the revenue proportion operational company shared, and $(1-\Phi 2)$ is offered to developer company

∂: the cost operational company offered to telecom company for each online game card

p: the retail price for each online game card retailer offered to online game player

q: the online game card quantity is ordered by retailer from operational company

$F(x)$: the probability distribution function for the demand quantity to online game card

$S(q)$: the expected sale quantity of online game card, and

$$S(q)=q-\int_0^q F(x)d(x)$$

π_1^0: the profit of retailer in the old contract
π_2^0: the profit of operational company in the old contract
π_3^0: the profit of developer in the old contract
π^0: the profit of the whole supply chain in the old contract
π_1: the profit of retailer in the new contract
π_2: the profit of operational company in the new contract
π_3: the profit of developer in the new contract
π: the profit of the whole supply chain in the new contract

3.2 Description for Operation Progress in the Old Contract

The operation progress in the old contract is described as Figure 1.

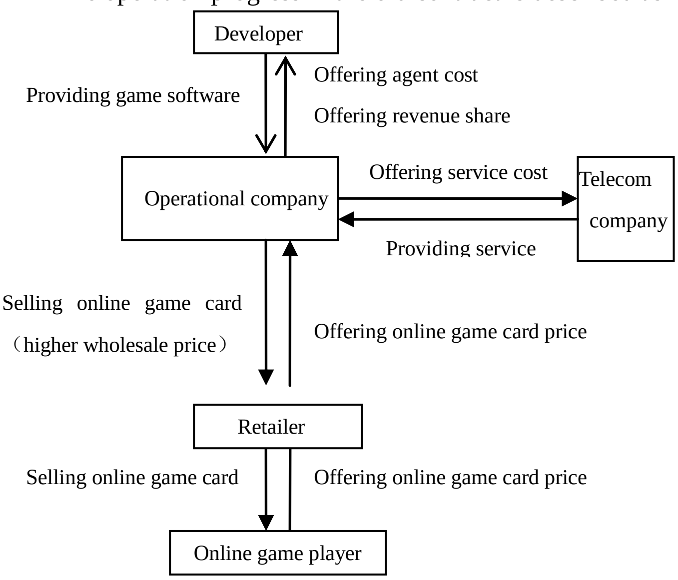

Figure 1. The operation progress in the old contract

3.3 the Old Contract Model

According to the description on the operational process of the old contract in the online game industry and relevant parameter, the profit equations for each company are provided:

the profit of retailer

$$\pi_1^{\circ}=\mathrm{p}\cdot S(q)-\omega_0\cdot q-\mathrm{c}_4 q-\mathrm{c}_5 \tag{1}$$

the profit of operational company

$$\pi_2^{\circ}=\Phi_2\omega_0\cdot q-\mathrm{c}_2 q-\partial\cdot S(q)-\mathrm{c}_1-\mathrm{c}_6 \tag{2}$$

The profit for developer

$$\pi_3^{\circ}=(1-\Phi_2)\omega_0\cdot q+\mathrm{c}_1\text{-c} \tag{3}$$

The profit for the whole supply chain

$$\pi^{\circ} = \mathrm{p} \cdot S(q) - \mathrm{c}_2 q - \mathrm{c}_4 q - \partial \cdot S(q) - \mathrm{c} - \mathrm{c}_5 - \mathrm{c}_6 \tag{4}$$

In order to get the optimal order quantity q^* to maximize the profit of the whole supply chain, we get the derivative about π°.

$$\frac{d\pi^{\circ}}{dq} = \mathrm{p} \cdot \frac{dS(q^*)}{dq} - \mathrm{c}_2 - \mathrm{c}_4 - \partial \cdot \frac{dS(q^*)}{dq} = 0$$

$$\Rightarrow \mathrm{p} \cdot [1 - F(q^*)] - \mathrm{c}_2 - \mathrm{c}_4 - \partial \cdot [1 - F(q^*)] = 0$$

$$\Rightarrow F(q^*) = \frac{(\mathrm{p} - \partial) - (\mathrm{c}_2 + \mathrm{c}_4)}{\mathrm{p} - \partial}$$

$$\Rightarrow q^* = F^{-1}[\frac{(\mathrm{p} - \partial) - (\mathrm{c}_2 + \mathrm{c}_4)}{\mathrm{p} - \partial}] \tag{5}$$

In order to get the optimal order quantity q° to maximize the profit of retailer, we get the derivative about π_1°.

$$\frac{d\pi_1^{\circ}}{dq} = \mathrm{p} \cdot \frac{dS(q^{\circ})}{dq^{\circ}} - \omega_0 - \mathrm{c}_4 = 0$$

$$\Rightarrow \mathrm{p} \cdot [1 - F(q^{\circ})] - \omega_0 - \mathrm{c}_4 = 0$$

$$\Rightarrow F(q^{\circ}) = \frac{\mathrm{p} - \omega_0 - \mathrm{c}_4}{\mathrm{p}}$$

$$\Rightarrow q^{\circ} = F^{-1}[\frac{\mathrm{p} - \omega_0 - \mathrm{c}_4}{\mathrm{p}}] \tag{6}$$

In fact, $\frac{\omega_0}{\mathrm{p}}$ is about 80%, $\frac{\partial}{\mathrm{p}}$ is about 4%, $\frac{\mathrm{c}_2 + \mathrm{c}_4}{\mathrm{p}}$ is about 0.5%,so it is easy to get the result $\frac{\mathrm{p} - \omega_0 - \mathrm{c}_4}{\mathrm{p}} < \frac{(\mathrm{p} - \partial) - (\mathrm{c}_2 + \mathrm{c}_4)}{\mathrm{p} - \partial}$, because $F(x)$ is the probability distribution function for the demand quantity to online game card, $F(x)$ is a monotony increasing function. So $F^{-1}(q)$ is also a monotony increasing function. It is easy to get the result

$F^{-1}[\frac{\mathrm{p} - \omega_0 - \mathrm{c}_4}{\mathrm{p}}] < F^{-1}[\frac{(\mathrm{p} - \partial) - (\mathrm{c}_2 + \mathrm{c}_4)}{\mathrm{p} - \partial}]$, namely $q^{\circ} < q^*$, so the whole supply chain do not get to coordination. This paper will validate with data analysis.

3.4 Reference to the Contracts in Traditional Industry

Thinking about the following reasons, this paper provides a new profits model for the supply chain in online game industry using the thought of revenue sharing. The thought of revenue sharing has been successfully used in the video rental industry, and the pivotal reason is that the rental quantities are monitored accurately using scanning beam at the doors of the video rental retailers.

However, there are some difference between online game industry and video rental industry. The key difference is that although the marginal manufacturing cost percent in retail price is very small in video rental industry, the marginal manufacturing cost percent in retail price is much smaller in online game industry. According to the thought of revenue sharing in video industry, operational company will sell the online game card to retailers with the price below the marginal manufacturing cost, but the marginal manufacturing cost itself is very little, about 0.02$, this means operational company gave gratis online game cards to retailers. Operational company does not agree with because operational company has offered to developer a large number fund for a power of attorney bearing all the risk. In order to deal with this problem, thinking about reducing the risk of operational company, the paper suggest that retailer should offer to operational company a fund for the license of online game card before the revenue sharing contract was designed between operational company and retailers. Thus operational company can take back part of large agent costs beforehand and reducing risk.

3.5 Description for Operation Progress in the New Contact

The operation progress in the old contract is described as Figure 2.

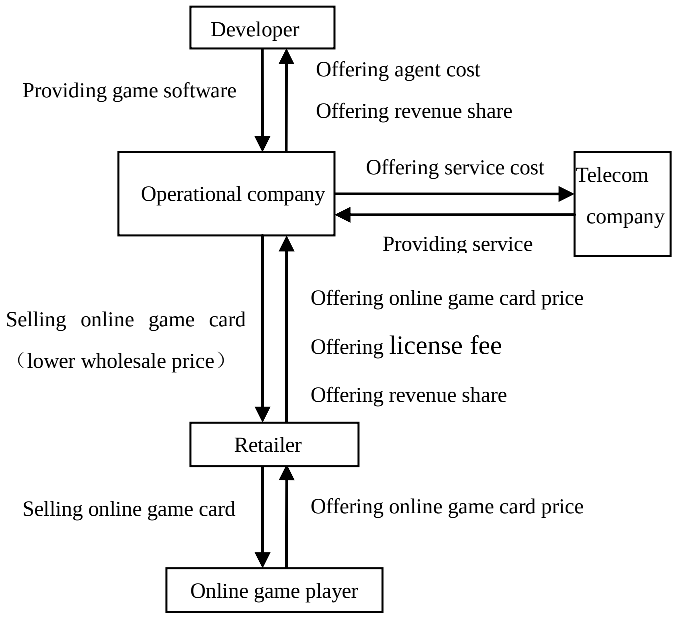

Figure 2. The operation progress in the new contract

3.6 Building the New Contract Model

According to the description on the operational process of the new contract in the online game industry and relevant parameter, the profit equations for each company are provided:

the profit of retailer

$$\pi_1 = \Phi_1\, p \;\; S(q) \;\; \omega \;\; q \;\; c -_4 q \;\; c -_3 \;\; c \tag{7}$$

the profit of operational company

$$\pi_2 = \Phi_2[(1-\Phi_1)\cdot \mathrm{p}\cdot S(q)+\omega\cdot q+\mathrm{c}_3]-\mathrm{c}_2 q-\partial\cdot S(q)-\mathrm{c}_1-\mathrm{c}_6 \tag{8}$$

the profit for developer

$$\pi_3 = (1-\Phi_2)[(1-\Phi_1)\cdot \mathrm{p}\cdot S(q)+\omega\cdot q+\mathrm{c}_3]+\mathrm{c}_1\text{-c} \tag{9}$$

the profit for the whole supply chain

$$\pi = \mathrm{p}\cdot S(q)-\mathrm{c}_2 q-\mathrm{c}_4 q-\partial\cdot S(q)-\mathrm{c}-\mathrm{c}_5-\mathrm{c}_6 \tag{10}$$

In order to get the optimal order quantity q^{**} to maximize the profit of the whole supply chain, we get the derivative about π.

$$\frac{d\pi}{dq} = \mathrm{p}\cdot\frac{dS(q^{**})}{dq}-\mathrm{c}_2-\mathrm{c}_4-\partial\cdot\frac{dS(q^{**})}{dq}=0$$

$$\Rightarrow \mathrm{p}\cdot[1-F(q^{**})]-\mathrm{c}_2-\mathrm{c}_4-\partial\cdot[1-F(q^{**})]=0$$

$$\Rightarrow F(q^{**})=\frac{(\mathrm{p}-\partial)-(\mathrm{c}_2+\mathrm{c}_4)}{\mathrm{p}-\partial}$$

$$\Rightarrow q^{**}=F^{-1}[\frac{(\mathrm{p}-\partial)-(\mathrm{c}_2+\mathrm{c}_4)}{\mathrm{p}-\partial}] \tag{11}$$

In order to get the optimal order quantity $q^{\circ\circ}$ to maximize the profit of retailer, we get the derivative about π_1.

$$\frac{d\pi_1}{dq}=\Phi_1\cdot\mathrm{p}\cdot\frac{dS(q^{\circ\circ})}{dq}-\omega-\mathrm{c}_4=0$$

$$\Rightarrow \Phi_1\cdot\mathrm{p}\cdot[1-F(q^{\circ\circ})]-\omega-\mathrm{c}_4=0 \Rightarrow F(q^{\circ\circ})=\frac{\Phi_1\cdot\mathrm{p}-(\omega+\mathrm{c}_4)}{\Phi_1\cdot\mathrm{p}}$$

$$\Rightarrow q^{\circ\circ}=F^{-1}[\frac{\Phi_1\cdot\mathrm{p}-(\omega+\mathrm{c}_4)}{\Phi_1\cdot\mathrm{p}}] \tag{12}$$

In order to make the whole supply chain get to coordination, the condition $q^{\circ\circ}=q^{**}$ must be satisfied.

$$\Rightarrow \frac{(\mathrm{p}-\partial)-(\mathrm{c}_2+\mathrm{c}_4)}{\mathrm{p}-\partial}=\frac{\Phi_1\cdot\mathrm{p}-(\omega+\mathrm{c}_4)}{\Phi_1\cdot\mathrm{p}}$$

$$\Rightarrow \omega=\frac{\Phi_1\cdot\mathrm{p}\cdot(\mathrm{c}_2+\mathrm{c}_4)}{\mathrm{p}-\partial}-\mathrm{c}_4$$

4. DATA ANALYSIS

In this paper, the demand quantity χ is random and submitted to normal distribution, namely $\chi\sim N(\mu,\sigma)$.

According to the data of the report on online game industry in China, the relevant parameter is listed in Table 2.

Table 2. Parameter and value

parameter	value	parameter	value
c	17000000	∂	2
c1	90000000	c6	30000000
c2	0.4	p	50
c3	35000000	c4	0.1
ω_0	35	Φ 1	30%
Φ 2	60%	c5	8000000
μ	40000000	σ	6000000

According to the value of parameter in Table 2, we can compute the profit of each company in the old contract model. According to the equation (5) and (6),

$$q^* = F^{-1}[\frac{(50-2)-(0.4+0.1)}{50-2}] = F^{-1}(0.9896) \Rightarrow q^* = 53865948$$

$$q^0 = F^{-1}[\frac{(50-35-0.1}{50}] = F^{-1}(0.2980) \Rightarrow q^0 = 36819031$$

Because $q^\circ < q^*$， the supply chain is not coordinated，and according to the equation (1),(2),(3),(4)

π_1°=483982213.84，π_2°=567098836.85，π_3°=588466438.62，π°=1639547489.31

Similarly, we can compute the profit of each company in the new contract model. According to the equation (11) and (12)

$$q^{00} = q^{**} = F^{-1}[\frac{(50-2)-(0.4+0.1)}{50-2}] = F^{-1}(0.9896) = 53865948$$

Because $q^{\circ\circ}$=q^{**}， the supply chain is coordinated，and according to the equation (7),(8),(9),(10)

π_1=548263728.51，π_2=640866621.53，π_3=647913581.20，π =1837043931.24

The profit of each company in the old contract model is compared with the profit of each company in the new contract model, the result is described as Table 3.

Table 3. Profit comparation

profit	retailer	operational company	developer	the whole supply chain
In the old contract	483982213.84	567098836.85	588466438.62	1639547489.31
In the new contract	548263728.51	640866621.53	647913581.20	1837043931.24
Increased profit	64281514.67	73767784.68	59447142.58	197496441.93
Increased rate	13.28%	13.01%	10.10%	13.28%

From Table 3, we can find out the profit of the whole supply chain is higher in the new contract than in the old contract, and the profit of each company is also differently higher than in the new contract than in the old contract. The parito improvement is achieved.

5. CONCLUSION

This paper provides a new supply chain contract model adapt to digital products such as online game, compares with the old model using simulation analysis. The old contract model in online game industry can not achieve coordination and causes the profit in whole supply chain not to achieve the optimization, but the new model can achieve coordination and the optimal profit in the whole supply chain, meanwhile the profits of all the companies will increase. The risk is spread around very well all the companies in the online game supply chain in the new contract model and the principle of revenue sharing and risk sharing in supply chain is embodied.

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