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Dynamic Pricing and Coordination of Telecom Supply Chain Based on Stackelberg Model under Mobile Terminal Customization

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Introduction

5G is increasingly becoming a key driver for the digitalization, networking, and intelligent transformation and upgrading of the economy and society. Each new generation of information technology promises to deliver enhanced communication service experiences to consumers. However, these advancements also bring about the necessity for consumers to pay higher fees for improved services. This often results in consumers hesitating to immediately replace their current smartphones and mobile communication services with 5G counterparts. They prefer to wait for a period of price reductions before considering an upgrade. On the other hand, for telecom operators, they want consumers to purchase 5G mobile phones and 5G communication services as early as possible in order to capture more revenue from 5G communication services.

Research problems

(1) In the face of consumers' strategic purchasing behavior, how should the telecom operator and the mobile phone manufacturer make pricing decisions in the case of mobile terminal customization?

(2) How to design the coordination mechanism among telecom supply chain members to achieve system optimization?

Models

(1) Integrated Scenario

$$p_2^{I*} = \arg\max_{p_2}\left[(p_2 - c)(V_1 - p_2) + \lambda p_2 (1 - V_1)\right]$$

$$V_1^{I*} = \inf\left\{V_1 \middle| V_1 - p_1 + \lambda\left(V_1 - p_2^{I*}\right)^+ \geq \left(V_1 - p_2^{I*}\right)^+\right\}$$

$$p_1^{I*} = \arg\max_{p_1}\left[(p_1 - c)\left(1 - V_1^{I*}\right) + \left(p_2^{I*} - c\right)\left(V_1^{I*} - p_2^{I*}\right) + \lambda p_2^{I*}\left(1 - V_1^{I*}\right)\right]$$

(2) Independent Scenario

$$p_2^{D*} = \arg\max_{p_2}\left[(p_2 - w)(V_1 - p_2) + \lambda p_2 (1 - V_1)\right]$$

$$V_1^{D*} = \inf\left\{V_1 \middle| V_1 - p_1 + \lambda\left(V_1 - p_2^{D*}\right)^+ \geq \left(V_1 - p_2^{D*}\right)^+\right\}$$

$$p_1^{D*} = \arg\max_{p_1}\left[(p_1 - w)\left(1 - V_1^{D*}\right) + \left(p_2^{D*} - w\right)\left(V_1^{D*} - p_2^{D*}\right) + \lambda p_2^{D*}\left(1 - V_1^{D*}\right)\right]$$

$$w^{D*} = \arg\max_{w}\left[(w - c)\left(1 - p_2^{D*}\left(p_1^{D*}\right)\right)\right]$$

Mechanism design

Under the implementation of the revenue sharing contract mechanism, the total profit function for the manufacturer over two cycles is as follows:

$$\pi_M^R = (w - c)(Q_1 + Q_2) + \varphi p_1 Q_1 + \varphi p_2 Q_2 + \varphi \lambda p_2 Q_1$$

The second cycle and two cycles profit functions for the telecom operator are as follows:

$$\pi_{T2}^R = \left((1-\varphi)p_2 - w\right)Q_2 + (1-\varphi)\lambda p_2 Q_1$$

$$\pi_T^R = \left((1-\varphi)p_1 - w\right)Q_1 + \left((1-\varphi)p_2 - w\right)Q_2 + (1-\varphi)\lambda p_2 Q_1$$

The revenue sharing contract can achieve perfect coordination of the telecom supply chain, if and only if the unit wholesale price and the revenue sharing ratio must satisfy:

$$\begin{cases} w^R = c(1-\varphi) \\ \dfrac{\left(1+4\lambda-\lambda^2-c(1+\lambda)^2\right)^2}{2(1+\lambda)^2\left(4\lambda^2+(1-c)^2(1+\lambda)^2\right)} \leq \varphi \leq \dfrac{\left(1+4\lambda-\lambda^2-c(1+\lambda)^2\right)\left(3+4\lambda+5\lambda^2-3c(1+\lambda)^2\right)}{4(1+\lambda)^2\left(4\lambda^2+(1-c)^2(1+\lambda)^2\right)} \end{cases}$$

Conclusions

(1) An increase in the proportion of communication service utility (PCSU) leads to a higher wholesale price and lower retail prices, which is advantageous for the handset manufacturer but may not be beneficial for the telecom operator.

(2) Enhancing PCSU can mitigate strategic consumer behavior, but it also exacerbates the gap between supply chain profits in two scenarios.

(3) Under certain conditions, the revenue sharing contract can achieve perfect coordination within the telecom supply chain.

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