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Research on the Service Fee Model based on Industrial Internet Platform

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Abstract

Value-added services based on the production side and demand side of the Industrial Internet platform not only allow for flexible integration and allocation of various resources, but also enable real-time information sharing and reduce transaction costs. Therefore, it is of comparative importance to study how to design a service fee model to incentivise manufacturing enterprises to rely on platform services to achieve digital transformation through information sharing. The study found that when value-added services are less effective, industrial internet platforms choose a pay-per-use model and manufacturers choose a subscription-based model; within a reasonable level of value-added services, supply chain profits under a subscription-based model are always better than pay-per-use.

Keywords

Industrial Internet Platform; Pay-per-use Model; Subscription Fee Model.

1. Introduction

Value-added services on industrial Internet platforms refer to the customization of services based on industrial Internet products or technologies, and are scalable in mode, including both value-added services in the ordinary sense and a wider range of extended services. This paper focuses on the pricing models between platforms and manufacturers, and examines the impact of subscription-based and usage-based models on platform and business decisions and profits in the context of platforms providing value-added services on the production and demand sides.

The subscription-based model, also known as the fixed-fee model, is where the industrial internet platform acts as a provider of services to its customers and the customer pays a corresponding fee to guarantee the normal use of the service within the time frame allowed by the contract. The subscription fee model may be limited in terms of scope and level of use, only allowing the user to call on the service for a contracted period of time, with no guarantee of satisfaction with the service. For example, Microsoft offers a wide range of office software that users can purchase on a monthly or annual basis depending on how long they use it, as well as campus licensing services that allow teachers and students unlimited access to the software, but the fees are not usually determined by the actual number of users.

Usage-based pricing is based on the actual usage of the service, measured in units of usage such as the number of users or transactions, which can be in terms of information storage capacity, the number of devices accessed and the number of products sold. Platforms prefer to offer a usage-based model to manufacturers because it allows SMEs that do not have sufficient funds to meet the subscription service requirements to participate and expand the market size of the platform. However, this is challenging for manufacturers as companies may face the possibility of not meeting their desired revenue.

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2. Literature References

A part of the scholars' research focuses on the level of charging models for information-based products or software services. Li [1] found relevant literature on SaaS between 2011 and 2021 and divided the research topics of SaaS services into two levels: pricing and operation, and proposed four pricing schemes: market entry, tariff, bundling and dynamic pricing, which illustrated the importance and complexity of pricing SaaS services. importance and complexity. Balasubramanian[2] compares two tariff models of selling information-based goods in advance versus pay-per-use and finds that pay-per-use is related to the psychological cost to consumers, and when the psychological cost is low, the pay-per-use mechanism is due to the sell-in-advance model. Gangwar & Bhargava [3] study confirms that combining a usage-based cost per unit and an access-based per-period fee combined as a two-part fee contract is a more beneficial benefit model for companies selling digital goods and helps to increase market size. Demirezen [4] designed three pricing models based on effort-based fees, per-output fees and mixed menus in the context of value co-creation between service providers and manufacturers, proposing and solving for a service where the provider and customer model that continues to yield benefits after the end of the service. Menon [5], through a theoretical research approach and a certain range of empirical studies, point out that Industrial Internet platforms are able to access, manage and control product-related data, information and knowledge across all phases of the life cycle, and propose solutions that use the openness and relevant dimensions and sub-dimensions of Industrial Internet platforms, validating the management implications of long-term and sustainable options for platforms. Yang [6] combine pricing strategies with platforming strategies in the context of network effects to analyse equilibrium decisions under four structures, and propose that platforms are best preceded by competitors adopt digital technology.

In contrast to the above studies, Pauli[7] point out that to successfully build digital industrial platforms, practitioners must carefully assess which established strategies can be built upon, which strategies need to be adapted to new contexts, and which entirely new strategies are necessary or feasible. Among others, the BISE research community provides very important guidance to practitioners that complexity and meaning can be identified as a need in the context of digital industrial platforms. Hartner[8] uses a value-oriented network approach to identify a total of eight clearly distinguishable platform models, based on the analysis of a study of over 160 platforms in the manufacturing industry, by defining business roles as well as revenue models and business relationships. These models and their value and revenue patterns are described in detail.

In considering a competitive market situation, Zhang [9], in an environment where software companies compete with new entrant SaaS providers, state that consumers are sensitive to upgrade costs and switching costs, and that flat pricing can be an effective competitive tool for software companies. Belhadj et al [10] study fixed pricing schemes and usage-based pricing schemes in a competitive environment, and find that If companies implement usage-based pricing, they incur transaction costs to monitor usage and suggest that managers should be cautious about implementing usage-based pricing in a competitive environment.

3. Fee-based Model for Value-added Services on the Production Side of the Platform

3.1. Model Description

The demand function for the market is:

$$q = \theta - p + \phi k \tag{1}$$

Industrial Internet platforms and manufacturers can maximise profits by jointly deciding on service levels, market unit prices and charging models. The platform provides production-side value-added services that help manufacturers to expand market demand and reduce manufacturing costs, and manufacturers pay for the appropriate level of service. Therefore, the profit function of an industrial internet platform is defined as follows:

$$\Pi_g = \mathrm{T}_{mg} - \tau k^2 \tag{2}$$

The manufacturer upgrades its manufacturing with the services provided by the platform and sells it to the market at a unit price. The manufacturer's profit function is therefore defined as follows:

$$\Pi_m = pq - (c - \mu k)q - \mathrm{T}_{mg} \tag{3}$$

3.2. Pay-per-use Model Benchmark (R Model)

The manufacturer will make pricing decisions based on its own a priori information about potential demand, with the following demand function and profit function for the platform and the manufacturer:

$$\begin{cases} q^{R-ns} = \beta\theta_H + (1-\beta)\theta_L - p + \phi k \\ \Pi_g^{R-ns} = \lambda\rho q - \tau k^2 \\ \Pi_m^{R-ns} = pq - (c - \mu k)q - \lambda\rho q \end{cases} \tag{4}$$

$$p - (c - \mu k) - \lambda > 0 \tag{5}$$

By solving the optimisation model by inverse induction, the optimal value-added revenue and profit for the platform, as well as the manufacturer and supply chain profit, can be obtained:

$$\Pi_g^{R-ns*} = \frac{\tau\left(\beta\theta_H + (1-\beta)\theta_L - c\right)^2}{8\tau - (\mu+\phi)^2} \tag{6}$$

$$\Pi_m^{R-ns*} = \frac{4\tau^2\left(\beta\theta_H + (1-\beta)\theta_L - c\right)^2}{\left((\mu+\phi)^2 - 8\tau\right)^2} \tag{7}$$

$$\mathrm{T}_{mg}^{R-ns*} = \frac{8\tau^2\left(\beta\theta_H + (1-\beta)\theta_L - c\right)^2}{\left((\mu+\phi)^2 - 8\tau\right)^2} \tag{8}$$

$$\Pi^{R-ns*} = \frac{\tau\left(\beta\theta_H + (1-\beta)\theta_L - c\right)^2\left(12\tau - (\mu+\phi)^2\right)}{\left((\mu+\phi)^2 - 8\tau\right)^2} \tag{9}$$

3.3. Subscription Fee Model Benchmark (F Model)

In a subscription fee model, the cost of a service subscription is proportional to the level of service k and is not related to the amount of usage of the platform q. As a result, manufacturers pay the following fees to the platform:.

$$\mathrm{T}_{mg}^{F-ns} = fk \tag{10}$$

where f denotes the manufacturer's subscription fee. Bringing this into the profit objective function yields:

$$\begin{cases} \Pi_g^{F-ns} = fk - \tau k^2 \\ \Pi_m^{F-ns} = pq - (c - \mu k)q - fk \end{cases} \tag{11}$$

$$p - (c - \mu k) > 0 \tag{12}$$

In a subscription fee model, where the manufacturer has greater bargaining power, the decision sequence is such that the manufacturer first decides on the subscription fee f and the unit sales price p , and then the Industrial Internet decides on the service level k .

By solving the optimisation model by reverse induction, the optimal unit rate, service level, unit sales price and product sales volume under the subscription fee model are substituted into the value-added revenue and profit function of the platform and the profit function of the manufacturer and supply chain to obtain:

$$\Pi_g^{F-ns*} = \frac{\tau(\mu+\phi)^2\left(\beta\theta_H + (1-\beta)\theta_L - c\right)^2}{\left(8\tau - (\mu+\phi)^2\right)^2} \tag{13}$$

$$\Pi_m^{F-ns*} = \frac{2\tau\left(\beta\theta_H + (1-\beta)\theta_L - c\right)^2}{8\tau - (\mu+\phi)^2} \tag{14}$$

$$T_{mg}^{F-ns*} = \frac{2\tau(\mu+\phi)^2\left(\beta\theta_H + (1-\beta)\theta_L - c\right)^2}{\left((\mu+\phi)^2 - 8\tau\right)^2} \tag{15}$$

$$\Pi^{F-ns*} = \frac{\tau\left(\beta\theta_H + (1-\beta)\theta_L - c\right)^2\left(16\tau - (\mu+\phi)^2\right)}{\left((\mu+\phi)^2 - 8t\right)^2} \tag{16}$$

3.4. Analysis of Equilibrium Results

Proposition1 (1) Under the pay-per-used fee model, there is a positive effect of μ on $\lambda^*, k^*, q^*, T_{mg}^*, \Pi_g^{R*}, \Pi_m^{R*}, \Pi^{R*}$.(2) Under the subscription fee model, there is a positive effect of μ on $\lambda^*, k^*, q^*, T_{mg}^*, \Pi_g^{R*}, \Pi_m^{R*}, \Pi^{R*}$.

Proposition 1 analyses the impact of the value-added service factor on the optimal decision by calculating the partial derivatives of the unit rate, service level, value-added service cost, profit of the industrial internet platform and the manufacturer's profit. When other variables are held fixed, an increase in product market size due to an increase in the level of value-added services is positively correlated with the value-added services factor. Proposition 1 shows that in both the R and F models, as the value-added service factor k increases, the level of service provided by the platform increases and the size of the manufacturer's market demand is positively correlated with the level of service, so that both the manufacturer's profit and the platform's value-added service revenue increase. This means that the increase in the level of value-added services requires the platform to incur more investment in research and development on the one hand, while on the other hand, it will also generate greater profits for the platform through market expansion and service revenues.

Proposition2 (1) When $4 < (\mu+\phi)^2/\tau < 8$, $T_{mg}^{F*} > T_{mg}^{R*}, \Pi_g^{F*} > \Pi_g^{R*}$;when $(\mu+\phi)^2/\tau < 4$, $T_{mg}^{F*} < T_{mg}^{R*}$, $\Pi_g^{F*} < \Pi_g^{R*}$.

(2) when $(\mu+\phi)^2/\tau < 6$, $\Pi_m^{F*} < \Pi_m^{R*}$; when $6 < (\mu+\phi)^2/\tau < 8$, $\Pi_m^{F*} > \Pi_m^{R*}$

(3) $\Pi^{F*} > \Pi^{R*}$

Proposition 2 finds that: (1) when the production-side value-added service effect factor of the platform exceeds a certain threshold, the platform's value-added service revenue is better than that of the R model in the F model; when the production-side value-added service effect factor of the platform is below a certain threshold, the platform's value-added service revenue is better than that of the F model in the R model;

(2) When the production-side value-added service effect factor is greater than a certain threshold value, manufacturers gain greater profits under the R model; when the production-side value-added service effect factor is less than a certain threshold value, manufacturers gain greater profits under the F model;

(3) The profit of the supply chain under the F model is always better than that under the R model. This is because in the R model, the industrial internet platform is not only in the upstream of the supply chain but also has stronger bargaining power, which leads to multiple marginal mark-ups and inefficiencies in the supply chain. In actual production activities, industrial internet platforms should focus more on the overall process of the supply chain and the way they cooperate with other players. Industrial Internet platforms are well placed to observe and control the supply chain process by differentiating services - upstream production-side value-added services and downstream demand-side value-added services.

3.5. Numerical Examples

This section will investigate the value of the production side of the platform's value added service effect with the platform's value added service revenue, platform profit, manufacturer profit, and overall supply chain profit by means of numerical arithmetic examples. Assuming that the parameters take the values of $\beta = 0.2$, $\theta_H = 10$, $\theta_L = 5$ and $c = 1$, the resulting images and conclusions are shown below:

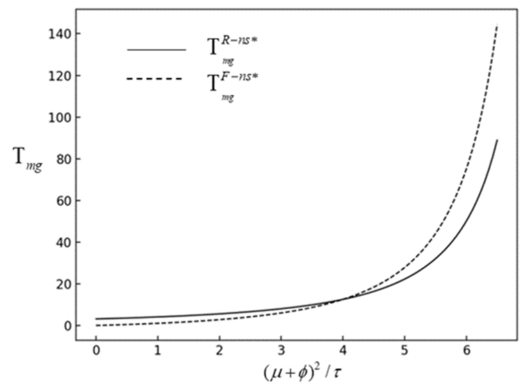

Figure 1. Comparison of the platform's value-added service benefits

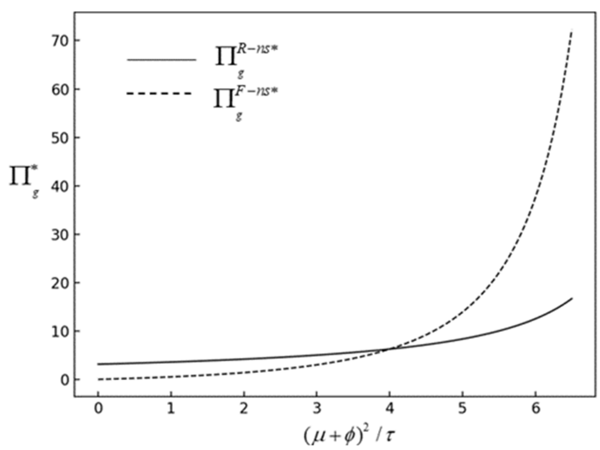

Figure 2. Comparison of platform profits

According to Figure 1 and Figure 2, without considering the demand-side value-added services, when the production-side value-added service effect of the platform is greater than the threshold value of 4, the platform under the F model obtains better value-added service revenue and profit; when the production-side value-added service effect of the platform is less than the threshold value of 4, the situation is reversed, and the value-added service revenue and profit of the industrial Internet-based platform under the R model is better than that of the F model.

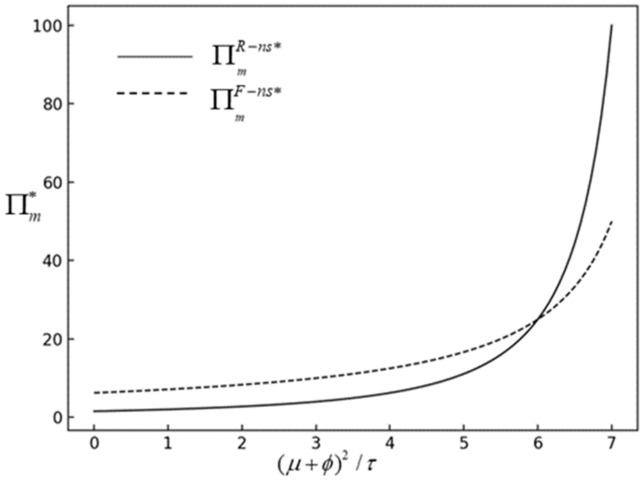

Figure3. Comparison of manufacturer profits

As can be seen from Figure 3, without considering demand-side value-added services, manufacturers in the R model are better off when the effect of the platform's production-side value-added services is greater than a threshold value of 6, and manufacturers in the F model are better off when the effect of the platform's production-side value-added services is less than a threshold value of 6.

4. Conclusion

Whether it is a pay-per-use model or a subscription fee model, the production-side value-added service factor and cost reduction factor have a positive impact on retail prices, market sales, value-added service revenue, platform profits and manufacturers' profits. When the effect of production-side value-added services is low, industrial internet platforms choose the pay-per-use model considering value-added service revenue, profit and the value of demand-side value-added services, while manufacturers will choose the subscription fee model. Within a reasonable range of value-added service levels, supply chain profits under the subscription fee model are always better than the pay-per-use model.

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