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Recommended Citation
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ANALYZING THE PRICING MODELS FOR OUTSOURCING COMPUTING SERVICES

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Abstract

With the prompt emergence of cloud computing service in recent years, the business software outsourcing model is giving way to the service-oriented paradigm. From the economic point of view, the pay-by-demand characteristic of cloud computing has significant advantage over self-owned software requiring tremendous upfront development cost and continuous maintaining effort. However, the public cloud computing service operated by external parties does have potential security risk the enterprises may face. In this paper, we utilize a game theoretic model to analyze the pricing strategies for computing services utilizing on-demand and built/licensed business models. We show that the price and revenue of computing service are significantly influenced by the market structure and technological parameters of computing service platform. Our analytical results provide useful business implications and operation strategies for the IT outsourcing computing service market.

Keywords: IT outsourcing, Cloud computing, On-demand model, Pricing strategy, Competition.
1 INTRODUCTION

As the IT industry changes rapidly and the elimination rate of technology advancement is increasingly high, it becomes a critical issue for firms to consider adopting the outsourcing strategy to survive in an increasingly competitive environment in recent decades. From the perspective of economic point of view, the main benefit from outsourcing specific functions of information system (IS) is cost reduction undoubtedly. Moreover, if a firm has particular demand on certain IT functions, which require specific professional knowledge unskillful to the firm, choosing an appropriate outsourcing enterprise partner could access leading-edge technology and sharpen focus on core competence (Clark JR et al. 1995; Takac 1994; The Yankee Group 1990). Along with the technology progress, there are several kinds of business solutions for enterprises to adopt as an outsourcing manner nowadays. The outsourcing type of an enterprise is dependent on its total assets, price of software, IT knowledge level of internal-business, the risk tolerance of the outsourcing function, scale of enterprise, and demand of service etc.

The notion of IT outsourcing could be traced back to the professional services and facility management services in the financial and operation support areas during the 1960s and 1970s (Lee et al. 2003). Since computer device was expensive and IT personnel is insufficient to satisfy the increasing demand of IT applications, facility management service and contract programming had become the primary form of outsourcing during 60’s and 70’s (Lee et al. 2003). In that times, enterprises choose non-core business operations like coding, customer relationship management, finance and human resources to outsource so as to save costs or expand other business service. However, the long-term contract and a large amount of expense will decrease the elasticity of decision-making and fund utilization. Besides, additional delay cost which is caused by the delayed delivery of the outsourcing provider or the shortage of IT-knowledge in software operational aspect are unavoidable negative impacts.

At the end of the 1990s, service provisioning in the form of ASPs (Application Service Provider) was considered as the new revolution for software (Vassiliadis et al. 2006). Service-oriented computing (SOC) supports the development of applications as if they were a connected network of functionalities (services) available in a network-enabled environment, within and across different organizations (Susaria et al. 2003). The occurrence of ASP and cloud computing gave birth to a pure service-oriented view of IT outsourcing. From a target market point of view, ASPs targeted mostly small and medium businesses (SMBs). These enterprises did not have the sufficient resource to invest in major systems like ERP and CRM and so they naturally became a key target for service provision vendors (Vassiliadis et al. 2006). Enterprise customers could pay the fees according to its practical usage instead of investing a large amount of money beforehand. Besides, the instant scalability feature of on-demand cloud computing service can resolve the enterprise’s capacity planning problem due to market uncertainty. However, once certain business function is moved to public cloud, the risks of confidential business information leakage and the cloud server’s crashing will arise necessarily.
Consequently, the higher demand of cloud computing service an enterprise needs, the more fees and risks it has to pay and face.

According to Gartner Inc, worldwide cloud services revenue is forecast to reach $68.3 billion in 2010, a 16.6 percent increase from 2009 revenue of $58.6 billion. Besides, the industry is poised for strong growth through 2014, when worldwide cloud services revenue is projected to reach $148.8 billion (Tudor & Pettey 2010). With the trend of cloud computing widely applied in several fields, enterprises have not only the option of traditional built/licensed software solution but also on-demand cloud computing service as outsourcing manners. Consequently, the IT outsourcing market concurrently consists of built/licensed software providers and cloud computing providers are currently competitive against each other. For instance, ERP service market is carved up by suit software like SAP and cloud computing service like Amazon.com and Salesforce.com. And Salesforce.com is also the best known for customer relationship management (CRM) enterprise cloud computing company. While developing appropriate pricing strategy to maximize the profit of computing service providers is becoming a significant issue to study, the analysis of business model adoption for various types of computing services and the impact of market interaction between the two kinds of computing service competitors are still ambiguous and relatively little attentions have been given to it. In this paper, we examine the impact of the market structure and technological characteristics on the pricing strategies and business models of outsourcing computing services. By considering key economic and technological parameters aligned with the realistic business decision, we suggest the feasible business models and pricing strategies and provide several insightful implications which are useful to aid the strategic manipulation of computing service providers.

The remainder of this paper is organized as follows. In section 2, we review previous literatures related to our research issue. In section 3, we propose an economic model of analyzing the adoption of computing service business model for a monopolistic provider and examine the pricing strategies between computing built/licensed software and on-demand cloud computing services. Finally, section 4 includes the conclusion of our insights and future research directions.

2 RELATED LITERATURE

2.1 IT Outsourcing and Cloud Computing

IT outsourcing was originated from the early 60’s, when it appeared in the form of application “time-sharing”. Service provision (or “software as a service”) has matured from the over-hyped application service provision model to the so called on-demand/utility computing (Serva et al. 2003). Owing to rapid expansion of the Internet and the emergence of cloud computing, the transition of the software industry into a service industry is becoming an inevitable fact. And following numerous opportunities are brought to the IT outsourcing market spontaneously. According to a report from research firm Gartner Inc, technology spending globally is estimated to rise by 5.1 percent in 2011. Gartner estimates the IT spending to reach $3.6 trillion in 2011, compared with $3.4 trillion last year.
Furthermore, business process outsourcing is estimated that by 2011 the world-wide market for business process outsourcing will reach $677 billion (IDC 2007).

Cloud computing service provides enterprises with a brand-new form of operational support solution, referring to the applications delivered as services over the Internet as well as the hardware and systems software in the data centers that provide those services (Armbrust et al. 2010). Cloud service permits system administrators to obtain general processing storage, database management, and other resources and applications through the Internet and pay only for the usage (Wyld 2009). According to the observation that for many services, the peak workload exceeds the average by factors of 2 to 10, cloud service captures the economic benefit to the enterprise customers and offers elasticity of investment for emerging and small-scale enterprises cloud service (Armbrust et al. 2010).

2.2 Software and Computing Service Pricing

The pricing strategy of the service-oriented provision is contrast to that of traditional application provision. The traditional application service providers sell the whole suit of software with a fixed amount of money; however, the service-oriented service providers offer computing resources in accordance with the demand of customer and charge by the amount of usage. The pricing strategy for cloud service has been studied in some previous studies (e.g. Niyato et al. 2009). With the emergence of on-demand computing service, such as SaaS, perpetual licensing and subscription based pricing schemes are compared by involving factors such as uncertain software quality in the future and network externality (Choudhary 2007; Zhang and Seidmann 2010). The current research focuses on the impact of the potential security risk the enterprises may face by adopting public cloud computing services on the resulting pricing scheme in different market structures. Nonlinear pricing model of information goods was proposed to analyze optimal pricing for information goods under incomplete information, when both unlimited-usage (fixed-fee) pricing and used-based pricing are feasible, and administrating usage-based pricing may involve transaction costs (Sundararajan 2004). Another pricing model for on-demand computing was established by modeling the optimal pricing of on-demand computing while taking certain critical factors into account (Huang and Sundararajan 2005). However, the above two pricing models were analyzed in a monopoly market. In our current pricing modeling research, both the computing service markets of monopoly and competition are considered to represent the distinct actual situations.

3 THE MODEL

We consider a market scenario in which enterprises need certain computing service to support their business operations. The computing service can be acquired via two feasible approaches in the market: on-demand cloud computing service or traditional licensed software service. The quantities of computing service required to satisfy its business operations of different enterprise customers vary. Leasing the on-demand computing service from cloud providers is more flexible as enterprise could setup the computing service quickly without huge upfront technology investment. However, leasing
cloud service takes potential information and/or hardware security risks which couldn’t be fully controlled or avoided by enterprise customers. Whereas, purchasing or building the self-own software could significantly remove the potential risk, but a large fixed technology cost which has to be paid to the software provider. In addition, no matter through purchasing or building, a development cost (e.g. the software couldn’t be accomplished on time or the software purchased couldn’t be operated in organization successfully) and/or system change cost (e.g. the system capacity scalability or business process adjustment due to the market demand uncertainty) will occur.

We assume that there are \( \eta_0 \) enterprises in various business domains. The expected revenue of a typical enterprise customer \( i \) is denoted as \( R_i \), which is uniformly distributed on \([0, \overline{R}]\). The demand of computing service required by enterprise customer \( i \) denoted as \( \lambda_i \), which is assumed to be uniformly distributed on an interval \([0, \overline{\lambda}]\), where \( \overline{\lambda} \) is the maximal demand of the computing service. For analysis convenience, we assume that the revenue of a form is positively associated with the amount of computing service. For analytical convenience, we assume \( R_i = \alpha \lambda_i \), where \( \alpha = \overline{R} / \overline{\lambda} \).

Purchasing or building self-owned software has lower security risk than leasing cloud service since enterprise customers can control the entire operational process instead of only relying the management of the on demand cloud computing service provider. However, whether the demand is abundant or lacking, enterprise customers have to pay a fixed upfront fee \( \phi \) to the software provider for installing the purchased/built software. Based on the IT knowledge level own by the enterprise customers, these customers could be classified into IT-skillful and IT-unskillful groups. We assume that \( \theta \) portion of the firms belongs to the IT-unskillful group and \( 1- \theta \) portion of the firms belongs to IT-skillful group. The development and change cost is generally higher for the IT-unskillful enterprises. Denote \( \sigma \in \{\sigma_H, \sigma_L\} \), as the cost of system development and change management. The enterprises with IT-unskillful knowledge incur a higher cost \( \sigma_H \); whereas the ones with IT-skillful knowledge incur a lower cost \( \sigma_L \). The payoff function of an enterprise \( i \) purchasing licensed software can be written as \( R_i - \phi - \sigma_i \).

Regarding the cost, on-demand cloud computing service is more flexible than traditional software as the enterprises can save the cost to purchase or build the software. In the initial phase of business establishment, firms generally lack the sufficient capital to invest a large-scale software for maintaining the essential operations. Leasing on-demand cloud computing service could solve this predicament as it is charged based on the actual amount of computing service executed. Assume the price of on-demand cloud computing (per unit of computing service) is \( p \) and the potential risk faced by the enterprise customers is \( \delta \), which is attached with each computing activity. The payoff function of an enterprise customer \( i \) adopting cloud computing service can be written as \( R_i - (p + \delta) \lambda_i \). Formally, an enterprise customer’s payoff on the basis of the level of IT knowledge can be represented
as follows:

\[
\pi_i(t) = \begin{cases} 
R_i - (p + \delta) \lambda_i & \text{if } t = c \text{ (cloud service is adopted)} \\
R_i - \phi - \sigma_i & \text{if } t = s \text{ (built/licensed software is adopted)} \\
0 & \text{otherwise}
\end{cases}
\]  

(1)

### 3.1 Service Model Adoption

**Licensing service model.** We first consider the scenario that the computing service provider adopts the business model of selling the licensed software. The profit-maximizing problem of the service provider can be formulated as:

\[
\begin{align*}
\max_{\phi} \Theta_i &= \phi \left( 1 - \frac{\phi + E(\sigma)}{R} \right) \eta_0 - K_i(\delta),
\end{align*}
\]

(2)

where \( E(\sigma) = \theta \sigma_{\|} + (1 - \theta) \sigma_{\perp} \) is the expected cost of system development and change. \( K_i(\delta) \) stands for technology development cost invested by the computing service provider to develop licensed software with quality level (easiness to use and change) \( \delta \), where \( \partial K_i(\delta) / \partial \delta < 0 \). Solving \( \frac{\partial \Theta_i}{\partial \phi} = 0 \), we have

\[
\phi^* = \frac{R - E(\sigma)}{2} \quad \text{and} \quad \Theta_i = \frac{(R - E(\sigma))^2}{4R} \eta_0 - K_i(\delta).
\]

(3)

**On-demand service model.** Next, we analyze the profit of the computing service provider if the on-demand business model is adopted. Denote the maximal computing demand of the subscribed enterprise customers as \( \hat{\lambda} \). The subscribed enterprise customers with demand less than \( \hat{\lambda} \) will use cloud computing service. According (1), the profit-maximizing problem of the computing service provider can be rewritten as:

\[
\begin{align*}
\max_p \Theta_e &= p \left( \frac{\hat{\lambda}^2}{2A} \right) \eta_0 - K_e(\delta),
\end{align*}
\]

(4)

where \( K_e(\delta) \) represents the technology development cost invested by the cloud computing service provider which is associated with risk level \( \delta \). \( \partial K_e(\delta) / \partial \delta < 0 \). Since condition \( \alpha \hat{\lambda} - (p + \delta) \hat{\lambda} \geq 0 \) should be satisfied to ensure non-negative profit for the enterprises, the optimal price and profit can be obtained as:

\[
p^* = \alpha - \delta \quad \text{and} \quad \Theta_e = \frac{1}{2} \left( R - \delta \hat{\lambda} \right) \eta_0 - K_e(\delta).
\]

(5)

**Mixed service model.** We then analyze the scenario that the computing service provider
adopts the mixed business model in which both licensed software and on-demand computing services are offered. According to the enterprise customer’s payoff function, we could infer that enterprises with higher computing demand $\lambda_i$ and lower development and change cost (business uncertainty) will choose to purchase/build self-owned software but enterprises with lower computing demand and larger development and change cost (business uncertainty) will choose on-demand cloud computing service to get a larger payoff. We could deduce indifference points $\hat{\lambda}_j$, $j \in \{H, L\}$ where the payoff will be equivalent regardless of leasing cloud service or purchasing traditional software. In other words, $\pi_i(c) = \pi_i(s)$ yields $\hat{\lambda}_j = \frac{\phi + \sigma_j}{p + \delta}$, $j \in \{H, L\}$. Notice that there are two difference demand points here because enterprise customers are classified into a group with either IT-skillful knowledge or with IT-unskillful knowledge. When an enterprise customer’s computing service demand surpasses the indifference point $\hat{\lambda}_j$, the customer will adopt purchasing/building software for a greater payoff; contrarily, if the amount of computing demand is less than indifference point, on-demand cloud computing service will be adopted. In the entire computing service market, the IT-unskillful companies occupying $\theta$ of the customers are separated based on the higher indifference point $\hat{\lambda}_H$; whereas the IT-skillful companies occupying $1-\theta$ of the customers are separated based on the lower demand indifference point $\hat{\lambda}_L$. The demand functions of the two types of computing service can be obtained as:

$$D_i(p, \phi) = \left( \theta \int_0^{\hat{\lambda}_H} \lambda f(\lambda) d\lambda + (1-\theta) \int_{\hat{\lambda}_H}^\lambda \lambda f(\lambda) d\lambda \right) \eta_0,$$

$$D_i(p, \phi) = \left( \theta \int_{\hat{\lambda}_L}^\lambda f(\lambda) d\lambda + (1-\theta) \int_{\lambda}^{\hat{\lambda}_L} \lambda f(\lambda) d\lambda \right) \eta_0,$$

where $f(\lambda) = 1/\lambda$ is the PDF of computing demand rate $\lambda$, which is assumed to be uniformed on interval $[0, \lambda]$. Denote $E\left(\sigma^2\right) = \theta \sigma_H^2 + (1-\theta) \sigma_L^2$. The demand functions can be obtained as:

$$D_i(p, \phi) = \frac{\phi + 2\phi E(\sigma) + E(\sigma^2)}{2\lambda (p + \delta)^2} \eta_0,$$

$$D_i(p, \phi) = \left( 1 - \frac{\phi + E(\sigma)}{(p + \delta) \lambda} \right) \eta_0.$$
Consequently, the profit structures of the on-demand cloud computing service and built/licensed software service can be expressed as:

$$\Theta_c = p \times D_c(p, \phi) - K_c(\delta),$$  \hspace{1cm} (10)

$$\Theta_i = \phi \times D_i(p, \phi) - K_i(\tau_0).$$  \hspace{1cm} (11)

The profit-maximizing problem of the computing service provider is written as follows:

$$\max_{p, \phi} \Theta_{c+i} = \Theta_c + \Theta_i.$$  \hspace{1cm} (12)

In order to achieve higher profit, the computing service provider can always raise the price of on-demand computing service $p$ to satisfy condition $\pi_i(c) = 0$. Solving $\partial \Theta_{c+i} / \partial \phi = 0$, we can obtain $\phi^* = \left(\frac{(p^* + \delta)^2 \lambda - \delta E(\sigma)}{p^* + 2\delta}\right)$. The optimal prices of on-demand computing and licensed software services are achieved as:

$$p^* = \alpha - \delta \quad \text{and} \quad \phi^* = \frac{\alpha^2 \lambda - \delta E(\sigma)}{\alpha + \delta}.$$  \hspace{1cm} (13)

**Proposition 1** The optimal service model and profit for a monopolistic computing service provider are:

$$\Theta_{c+i}^* = \begin{cases} \left(\frac{\bar{R} - E(\sigma)}{4\bar{R}}\right)\eta_0 - K_c(\sigma) & \text{if } E(\sigma) \leq \bar{R} \leq \delta \bar{\lambda} \\ \left(\frac{(\alpha^2 \lambda - \delta E(\sigma))^2 + (\alpha^2 - \delta^2)E(\sigma^2)\eta_0}{2\lambda \alpha^2 (\alpha + \delta)}\right) - K_i(\sigma) - K_c(\delta) & \text{if } \bar{R} \geq \max \left(\delta \bar{\lambda}, E(\sigma)\right) \\ \frac{(\bar{R} - \delta \bar{\lambda})\eta_0}{2} - K_c(\delta) & \text{if } \delta \bar{\lambda} \leq \bar{R} \leq E(\sigma) \end{cases}$$  \hspace{1cm} (14)

where (12), (13), (14) indicates the condition that the business model of pure built/licensed software selling, mixed licensed software and on-demand computing service, pure on-demand computing service respectively.

Proposition 1 indicates that a mixed revenue model can bring more profit only when the marginal value creation rate of computing service for the enterprise is sufficiently high.

Examining and comparing (3), (5), and (13), we have the following results.

**Corollary 1** The price of built/licensed software in a pure software selling business model is lower than that in a mixed business model. However, the price of on-demand cloud computing service in a pure on-demand business model is identical to that in a mixed business model.
Corollary 2. In a mixed business model, the drawback of on-demand service (e.g. security risk) not only has negative impact on the price of on-demand service but also the price of built/licensed software. However, the drawback of built/licensed software (e.g. system development and change cost) has only negative impact on the price of built/licensed software.

3.2 Computing Service Pricing Under Competition

In this section, we analyze the pricing strategy under the scenario that the built/licensed software and cloud computing service are operated by two competitive firms. The profit-maximizing problems of the providers are rewritten as: 
\[
\max_p \Theta_c(p, \phi^*) \quad \text{and} \quad \max_{\phi} \Theta_i(p^*, \phi).
\]
Solving \( \partial \Theta_c / \partial p = 0 \) and \( \partial \Theta_i / \partial \phi = 0 \) simultaneously, we yield the Nash equilibrium outcome as:

Proposition 2 The equilibrium prices and profits of competing on-demand computing and built/licensed software service providers are:

\[
\begin{align*}
 p^* &= \delta, \\
 \phi &= \delta \tilde{\alpha} - \frac{E(\sigma)}{2}.
\end{align*}
\]

Examining (17)-(18), we have the following observations.

Corollary 3 Although the price of built/licensed software decreases with the system development and change cost, which is similar to the scenario of monopolistic pricing. However, contrary to the monopolistic pricing strategy, the price of on-demand computing service and built/licensed software in competing market increases with the potential security risk.

Examining (19)-(20), we have the following observations.

Corollary 4 The revenue of on-demand cloud computing provider increases with the potential security risk as well as the system development and change cost. However, the revenue of built/licensed software decreases with the system development and change, it increases with the potential security risk.
Corollaries 3 and 4 demonstrate the power of competition effect in computing service pricing. Contrary to the monopolistic market, in competitive market, the drawback of cloud computing service does not decline the price and revenue of cloud computing service. As a result, the cloud computing service provider has less incentive to improve its service quality if the potential market is not enlarged.

4 CONCLUSION

In this paper, we study the pricing issue of various computing service models. The optimal service model with respect to certain specific market condition is analyzed. The distinct characteristics of two popular approaches – on-demand cloud computing and built/licensed software services are formulated and the impact of the technological and market factors on developing the pricing strategies under different scenarios of market interactions are also analyzed. We find that the factors affecting the prices of the cloud computing service and built/licensed software under the monopolistic and competing markets are significantly different. For example, the price and revenue of cloud computing service are negatively associated with the security risk in a monopolistic market but are positively associated with the security risk in a duopolistic market. As a result, a monopolistic computing service provider has incentive to invest appropriate IT to enhance the security quality in cloud service. However, in a competing market, the cloud computing service provider has less incentive to improve its service quality if the potential market is not enlarged.

There are several research directions to extend the current work. First, the issue of quality of service in cloud computing can be further modeled and examined. A natural extension is to include the factor such as the network congestion and reliability. Second, the impact of usage based pricing scheme of cloud computing can be further developed and analyzed. For example, it will be interesting to design non-linear pricing contact formats to attract enterprise users with heavy computing demand. Third, from the perspective of service pricing, different types of pricing schemes (such as subscription and usage based pricing) can be further proposed and compared. Finally, as the results are mainly explored based on analytical models, further relevant empirical studies on the cloud service adoption are helpful for the validation of the analytical findings.

ACKNOWLEDGEMENT

The authors are grateful for the financial support of National Science Council (NSC: 99-2410-H-009-035-MY2).

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