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Information Technology Outsourcing Incentive Research of Bilateral Moral Hazard of Output Elasticity

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Abstract

The study constructs general motivation model of technology outsourcing of bilateral moral hazard and mainly analyzes impact that principal and agent's output elasticity influence on sharing ratio and variable profit. The main conclusions are as following: Firstly, sharing ratio is determined by output elasticity, the side that owns bigger output elasticity will have higher sharing proportion from the output, especially when their output elasticity equal, sharing ratio is 0.5; secondly, respective variable profit also depends on output elasticity, the side that owns bigger output elasticity will have more variable profit.

Key words: Bilateral moral hazard; Output elastic; IT outsourcing; Incentive

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INTRODUCTION

Since Kodak Company outsourced their IT business to IBM, IT outsourcing has become more and more popular in the world: Firstly, IT outsourcing has held higher proportion in practical outsourcing market; secondly, IT outsourcing has got more attention from academic community. Some scholars pointed out that IT outsourcing can bring organization benefits, such as improving organizational performance (Gilley & Rasheed, 2000), sustaining competitive advantage (Sadiq, 2011), increasing business efficiency (Agrawal & Haleem, 2013), stimulating innovation (Su, Levina, & Ross, 2016), etc.. However, some also believed IT outsourcing was evil and had many risks, such as can bring weakened management (Earl, 1996), huge intangible cost (Barthelemy, 2001), etc.. Whatever the relationship between IT outsourcing and organizational performance is, IT outsourcing has become one economic trend (Chen & Bharadwaj, 2009).

In the actual IT outsourcing market, there is adverse selection and moral hazard problems because of information asymmetry between the principal (the client) and the agent. According to principal-agent theory, to solve adverse selection and moral hazard only depends on effective contract design and incentive mechanism design (Shi & Wang, 2011; Song, Dan, & Zhang, 2011).

Now the question is: Can the principal influence the output? In this paper, our answer is yes. Some literatures concluded that the success of outsourcing depended on mutual cooperation, trust, knowledge sharing, relationship quality (Wang & Shen, 2012; Song, Du, & Ai, 2013; Qi, & Chau, 2013), etc.. However, these conditions are determined by mutual efforts, namely the principal can affect output more or less.

How mutual effort of the principal and the agent influences output under bilateral moral hazard? How to design incentive mechanism under bilateral moral hazard? Huang et al. (2011) studied how to make use of profit distribution mode to encourage the principal and the agent to tell the truth and invest more resources in outsourcing. Song et al. (2011) researched incentive mechanism of service outsourcing of bilateral moral hazard. Olmos (2011) researched the effectiveness of liner sharing contract to ensure food quality. Dai et al. (2014) applied team production model and Nash negotiation model to explore the optimal linear sharing contract of services outsourcing under bilateral moral hazard. The paper plans to construct general incentive model of bilateral moral hazard and mainly discuss the incentive mechanism design of IT outsourcing basing on Holmstrom and Milgrom's analysis method (Bengst & Paul, 1987) and principal-agent theory.

1. METHODS AND PROBLEMS DESCRIPTION

As literature mainly applied mathematical modeling to solve problems of incentive mechanism design, therefore the paper decides to apply mathematical modeling to do research.

Assumption 1: The effort level of the principal and the agent are e_1, e_2 respectively. Similar to the Cobb-Douglas production function, the output function of outsourcing is $\pi = e_1^m e_2^n + \varepsilon$, $m, n \in (0,1)$ and m, n represents respective output elasticity, measuring the extent that effort level contributes to the output. Variable ε measures external uncertainties that may impact the output and it symbolizes uncontrollable conditions in the process of outsourcing. $\varepsilon \in N(0, \sigma^2)$.

Assumption 2: Both sides have costs because efforts also need resource investment. The principal and the agent's cost function are $0.5e_1^2$, $0.5e_2^2$ respectively. We can find that with the effort level increasing, the cost increases correspondingly.

Assumption 3: After signing the contract, the principal will pay fixed cost α firstly, α is a constant. Then, both sides will determine revenue sharing ratio β according to final output, $\beta \in (0,1)$. Namely, the payment mode is $\alpha+\beta\pi$. Sharing ratio β is also called residual claims. Obviously, the bigger the sharing ratio is, the more can get from the output. Meanwhile, both are risk neutral. Profit of the principal is $E\pi_1 = -\alpha+(1-\beta)e_1^m e_2^n - 0.5e_1^2$, profit of the agent is $E\pi_2 = \alpha+\beta e_1^m e_2^n - 0.5e_2^2$.

On the basis of above assumptions, general incentive model of IT outsourcing of bilateral moral hazard can be constructed as following:

$$\text{Max-}\alpha + (1-\beta)e_1^m e_2^n - 0.5e_1^2 , \tag{1}$$

$$\alpha + \beta e_1^m e_2^n - 0.5e_2^2 \geq \bar{\omega} , \tag{2}$$

$$e_1, e_2 \in \arg\max E\pi_1, E\pi_2 . \tag{3}$$

Formula (1) is the object function to pursue maximum profit of the principal; Formula (2) means profit of the agent is at least bigger than his reserved profit $\bar{\omega}$ or opportunity cost $\bar{\omega}$, $\bar{\omega}$ is a constant; Formula (3) is the motivation condition, it ensures maximum effort level of both sides.

2. MODELING ANALYSIS

Calculating partial derivative of Formula (3), we can obtain:

$$n\beta e_1^m e_2^{n-1} - e_2 = 0 . \tag{4}$$

Combining Formula (2) and (1), adding Formula (2) to Formula (1), we can get total profits:

$$E\pi_1 + E\pi_2 = e_1^m e_2^n - 0.5e_1^2 - 0.5e_2^2 - \bar{\omega} . \tag{5}$$

Calculating partial derivative of Formula (1), we can obtain:

$$m(1-\beta)e_1^{m-1}e_2^n - e_1 = 0 . \tag{6}$$

Solving simultaneity equations of Formula (4) and (6), we can get $e_1/e_2 = \sqrt{\frac{m(1-\beta)}{n\beta}}$ and:

$$e_1 = m^{\frac{2-n}{2(2-m-n)}}(1-\beta)^{\frac{2-n}{2(2-m-n)}}(n\beta)^{\frac{n}{2(2-m-n)}} , \tag{7}$$

$$e_2 = m^{\frac{m}{2(2-m-n)}}(1-\beta)^{\frac{m}{2(2-m-n)}}(n\beta)^{\frac{2-m}{2(2-m-n)}} . \tag{8}$$

Taking Formula (7) and (8) to Formula (5), we can get total profits:

$$\frac{1}{2}m^{\frac{m}{2-m-n}}n^{\frac{n}{2-m-n}}(1-\beta)^{\frac{m}{2-m-n}}\beta^{\frac{n}{2-m-n}}(2-m+m\beta-n\beta). \tag{9}$$

Calculating maximal value of (9), namely calculating first-order derivative of β, we can get:

$$\frac{2}{(2-m-n)}\beta^{\frac{2n-2+m}{2-m-n}}(1-\beta)^{\frac{2m-2+n}{2-m-n}}[n-2n\beta-0.5mn+mn\beta-m\beta^2+n\beta^2]. \tag{10}$$

Formula (11) can be regarded as the condition that satisfies maximum total profits of both sides. As $m, n \in (0, 1)$, whether the value of (11) is positive or negative, it relies on (11) as follows:

$$[n - 2n\beta - 0.5mn + mn\beta - m\beta^2 + n\beta^2] . \tag{11}$$

Proposition 1 Sharing proportion depends on the respective output elasticity. When the principal's output elasticity is bigger than the agent's, the sharing proportion of the principal is bigger than 0.5; vice versa. When their output elasticity equal, sharing proportion is 0.5, namely they each get one half outputs.

Proof: Because proving it directly is very complex and difficult, the paper tries to solve it indirectly from relations between the roots and the coefficients of quadratic function. When $m \neq n$, Formula (11) can be translated to:

$$(n-m)\beta^2 + (mn-2n)\beta + (n-0.5mn) = 0 . \tag{12}$$

Formula (12) can be translated to be quadratic function and define :

$$f(\beta) = (n-m)(\beta + \frac{mn-2n}{2n-2m})^2 + (n-0.5mn) - \frac{(mn-2n)^2}{4(n-m)} . \tag{13}$$

If $f(\beta)$ is quadratic function, (14) can be defined as the condition that $f(\beta)=0$ has real roots:

$$\Delta = (mn-2n)^2 - 4(n-m)(n-0.5mn) = mn(mn-2m-2n+4). \tag{14}$$

When $mn - 2m - 2n + 4 > 0$, $f(\beta) = 0$ have two different real roots, define them as β_1, β_2. If $m < n$, the symmetry axis of $f(\beta)$ function graph is $\beta = \frac{2n - mn}{2n - 2m} > 0$, minimal value of $f(\beta)$ is $f(\frac{2n - mn}{2n - 2m}) = \frac{-mn(mn - 2m - 2n + 4)}{4n - 4m} < 0$, and $f(0) = \frac{n}{2}(2 - m) > 0$, and $f(\frac{1}{2}) = \frac{n - m}{4} > 0$, $f(1) = \frac{m}{2}(n - 2) < 0$. Therefore, function graph of $f(\beta)$ is similarly as figure 1 shows. In Figure 1, we can find $B(\beta_1,0)$, $C(\beta_2,0)$ are crossover points that $f(\beta)$ crosses with X axis. Actually $B(\beta_1,0)$, $C(\beta_2,0)$ are roots of $f(\beta) = 0$. In the Figure 1 we can see $0.5 < \beta_1 < 1 < \beta_2$, $\beta \in (0,1)$, therefore only β_1 is efficient solution of $f(\beta) = 0$.Therefore, $0.5 < \beta < 1$. Likewise, if $n < m$, we can prove the function graph of $f(\beta)$ is shown as Figure 2. In Figure 2, we can find $\beta_1 < 0 < \beta_2 < 0.5 < 1$, $\beta \in (0,1)$, therefore only β_2 is efficient solution of $f(\beta) = 0$. Therefore, $0 < \beta < 0.5$.

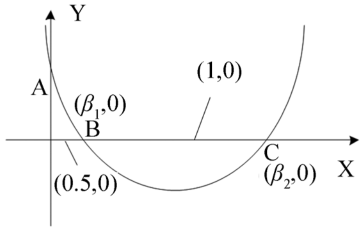

Figure 1
f(β)* Function Graph *(m<n)

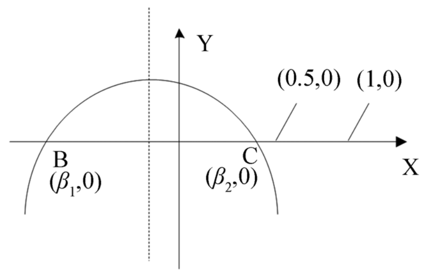

Figure 2
f(β)* Function Graph *(n<m)

Proposition 2 Both sides' variable profit is determined by respective output elasticity, namely:

Without considering α, when the principal's output elasticity is bigger, he can get more variable profit; vice versa; when their output elasticity equal, their variable profits equal.

Proof: From the above, we can know each profit is
$E\pi_1 = -\alpha + (1 - \beta)e_1^{\,m}e_2^{\,n} - 0.5e_1^2$, $E\pi_2 = \alpha + \beta e_1^{\,m}e_2^{\,n} - 0.5e_2^2$.

If we do not take fixed payment α into consideration, define Formula (16) as the difference of $E\pi_1$, $E\pi_2$ (do not consider α):

$$[(1 - \beta)e_1^{\,m}e_2^{\,n} - 0.5e_1^2] - [\beta e_1^{\,m}e_2^{\,n} - 0.5e_2^2] = [(1 - 2\beta)e_1^{\,m}e_2^{\,n} + 0.5(e_2^2 - e_1^2)] \ . \tag{15}$$

After simplified calculation, we can get:

$$m^{\frac{m}{2-m-n}} n^{\frac{n}{2-m-n}} (1-\beta)^{\frac{m}{2-m-n}} \beta^{\frac{n}{2-m-n}} [\beta(m+n-4)+2-m] \cdot \tag{16}$$

$m,n \in (0,1)$, $\beta \in (0,1)$,we can conclude: Whether the value of Formula (16) is positive or negative, it depends on $\beta(m + n - 4) + 2 - m$.

If $n < m < 1$, $0 < m + n < 2$, then $-4 < m + n < -2$; according to proposition 1, $0 < \beta < 0.5$, then $-2 < \beta(m + n - 4) < -1$; as $1 < 2 - m < 2$, $\beta(m + n - 4) + 2 - m > 0$.

Likewise, we can prove if
$m < n, \beta(m + n - 4) + 2 - m < 0. m = n, \beta(m + n - 4) + 2 - m = 0.$

CONCLUSION

The paper constructs general incentive model of IT outsourcing of bilateral moral hazard basing on principal-agent theory and explores the impact that respective output elasticity influences the sharing proportion and their variable profit. The conclusions are mainly as following. Firstly, sharing ratio is determined by respective output elasticity. The side that has bigger output elasticity will have more than 0.5 sharing proportion, namely he can ask more residual claim from the final output compared with the other side. Secondly, if do not consider α, both sides' variable profit are also determined by output elasticity: The side that has bigger output elasticity will have more variable profit. Thirdly, output elasticity is so important that it can impact sharing ratio and respective profit theoretically.

The conclusions are beneficial to both theory research and practitioner of IT outsourcing. However, the paper also needs improvement in the future research such as taking the principal and the agent's risk preference into consideration. This is the direction of future research.

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