Producer Services Outsourcing Risk Control Based on Outsourcing Contract Design: Industrial Engineering Perspective

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Abstract

Producer services outsourcing is facing many risks. If the outsourcing enterprise can’t carry on the analysis, appraisal and control of producer services outsourcing sufficiently, then the outsourcing enterprise not only can’t obtain benefits, but also has the inestimable loss from the outsourcing. This paper analyzes risk factors of producer services outsourcing, from the perspective of engineering, the paper affords managers a theoretic method to control outsourcing risks by designing the incentive and monitoring mechanism of the producer services outsourcing contract.

Keywords: Producer services outsourcing; Outsourcing risks; Contract design; Outsourcing engineering management

1. Introduction

The essence of producer services outsourcing is a kind of "principal-agent" relationship between the Outsourcing entrusted business and Outsourcing agents. Because of the Information asymmetry, Information distortion and the uncertainty of the market environment, there are kinds of risks when enterprises implement producer services outsourcing.

Quinn & Hilmer (1994) figured out three main risks of outsourcing strategy: lost the key capability or develop the wrong capability; lost the interactive capability of research and develop, produce and marketing; lost the capability of controlling outsourcing agents. Vandenber & Rogers (2000) pointed out that vision, knowledge sharing, trust, value increase and implementation and monitoring of process are the key factors to make outsourcing success. Ojelanki K Ngwenyama & William E. Sullivan (2007) analyzed how to avoid risks from the perspective of outsourcing contract designing.

The uncertain outsourcing environment and the information asymmetry in the outsourcing relationship makes enterprises take actions according to enterprises’ profit, in order to prevent outsourcing agents’ opportunistic behavior. Service outsourcing contract sets the rights and obligations between outsourcing entrusted business and outsourcing agents, which are the bonds of them and provides the base for successfully implanting the outsourcing (Davis, 2004). Elaborate and effective service outsourcing contract can low the risk brought by the information...
asymmetry (Tseng et al., 2009). Although there were outsourcing contracts concerned on information asymmetry, the common outsourcing contract did not take customer enterprises’ will into consideration, which made the service outsourcing contract do not match service production characteristics, and buried the hidden trouble for the implantation of outsourcing service project.

2. Risks identification

2.1. Tables

It should be noted that after the study of producer services outsourcing risk, we summarize that the outsourcing risk mainly arises from two periods: outsourcing decision and outsourcing execution, as showed in TABLE 1:

Table 1. Producer Services Outsourcing Risk Source

<table>
<thead>
<tr>
<th>Producer Services Outsourcing Risk Source</th>
<th>Outsourcing Decision Stage</th>
<th>Outsourcing Execution Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strategy risk</td>
<td>Management risk</td>
</tr>
<tr>
<td></td>
<td>Transaction risk</td>
<td>Relationship risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Out-of-control risk</td>
</tr>
</tbody>
</table>

2.2. Structure

Producer services outsourcing risk contains strategy risk, transaction risk, management risk, relationship risk and out-of-control risk. After the study of the factors of the risk, we get the fishbone diagram as figure 1 (Sanfa Cai et al., 2009):

Fig. 1. Producer Services Outsourcing Risk Source Fishbone Diagram

(1)------Lacking of effective incentive mechanism
(2) Competition mechanism is not sufficient
(3) Business process in disorder
(4) Lacking of effective producer services management performance estimation system
(5) Culture difference and unsatisfactory communication
(6) Lacking of executable service level agreement
(7) Lacking of recurrent job examination
(8) Vendor supervision is deficient
(9) Determination of outsourcing limit is indistinct
(10) Lacking of market maturity analysis
(11) Key business identification is not sufficient
(12) Contract clause is not perfect
(13) Lacking of professional outsourcing team

3. Outsourcing Contract Design

3.1. The Need for Outsourcing Contract

The relationship between manufacturing services outsourcing enterprises and the outsourcing provider is essentially a kind of principal-agent relationship based on contract. For cooperation, mutual members are requested to provide information, take risks and get paid together, but the partners, when in the pursuit of maximizing their own interests, the outsourcing provider would often maximize its own interests at the expense of the outsourcing enterprise, leading to a conflict of interest between the two sides. Therefore, in order to balance these conflicting interests, it needs to develop a series of contracts to achieve both goals. Whether the contracts are valid and could maximize the effectiveness of the two sides depend on whether the information is symmetry between the principal and the agent in the process of designing the contract, implementing the contract and evaluating the contract. In the outsourcing market, when the targets were not met, the outsourcing company does not know which is to blame, the outsourcing providers lacking hard work or the exogenous risks. Therefore, the information about the agent's effort is much-needed for the principal, however, such information is the agent's private information. So in the face of interests conflicts and the agent's moral hazard arising from asymmetric information, the principal must take incentive and restraint mechanisms to solve the problems.

3.2. Incentive and Monitoring Model under Uncertain Information

3.2.1 Model assumptions

In the principal-agent relationship, the principal would like to choose an agent in accordance with the interests of the principal, but the agent's actions can not be observed directly, and only a few variables can be observed. These variables are decided by the agent's actions and other exogenous random factors, which is the agent's incomplete information. According to the incomplete information, the principal rewards the agent to encourage it to choose the most favorable action and to reduce the likelihood of risk.

To be able to model the principal-agent theory, make the following assumptions:

(1) Assuming \( A \) is a collection of all actions the agents could choose, and \( a \) is a particular action which can be any dimension of the decision variable. \( a \in A \). In order to analyze the problem simpler, here \( a \) is one-dimensional variable of the agent's effort level.

(2) \( \theta \) is exogenous random variables and is not subject to the control of the agent and the principal of, which is known as the "natural state", \( t_i \) is the range of \( \theta \), the distribution function and density function of \( \theta \) in \( t_i \) is \( G(\theta) \) and \( g(\theta) \) respectively.

(3) After the agent chooses action \( a \), the exogenous variable \( \theta \) is obtained. \( a \) and \( \theta \) together determine an observation result \( x(a, \theta) \) and an output \( \pi(a, \theta) \), in which \( \pi(a, \theta) \) is directly belongs to the principal.
(4) $\pi$ is assumed to be strictly increasing concave function of $a$, that is, given $\theta$, the harder the agent works, the higher is the output, but the marginal productivity rate of the efforts diminishes; $\pi$ is strictly increasing function of $\theta$, that is $\theta$ represents higher favorable natural state. At this point, the principal could design an incentive contract $s(x)$ to reward agents according to the observed result $s(a, \theta)$.

Assumed that the expected function of the principal and the agent respectively are $v(\pi - s(x))$ and $u(s(\pi) - c(a))$, where $c(a)$ is the agent's effort cost function. $v' > 0, v' \leq 0; u' > 0, u' \leq 0; c' > 0, c' > 0$. In other words, the principal and the agent are risk averse, or at least they are risk neutral, and negative marginal utility of the agent's effort is increasing. The interests conflict of the principal and the agent comes from assuming $\frac{\partial \pi}{\partial a} > 0$ and $c' > 0$ first; $\frac{\partial \pi}{\partial a} > 0$ means how hard the principal wants the agent to work, and $c' > 0$ means that the agent hope for less effort.

Therefore, unless the principal could provide the agent sufficient incentive, otherwise, the agent would not work hard as the principal hopes. Therefore, the principal's expected utility function can be expressed as this:

$$\int (v(\pi(a, \theta)) - s(x(a, \theta)))g(\theta)d\theta \quad (P)$$

The principal selects $a$ and $s(x)$ to maximize the expected utility function, when doing so, the principal also faces the following two constraints from the agent:

(1) First is the agent's participation constraint. The agent would accept the contract when the expected utility is not less than the maximum expected utility under no contracts. The maximum expected utility is decided by other market opportunities, and it can be called as the reservation utility which uses $u$ to represent. Therefore the constraint can be expressed as:

$$\int u(s(x(a, \theta)))g(\theta)d\theta - c(a) \geq \bar{u} \quad (IR)$$

(2) Second is the agent's incentive compatibility constraint. The principal can not observe the agent's action $a$ and the natural state $\theta$, and under any incentive contract, the agents always choose the action $a$ to maximize their own expected utility. Therefore, the principal's expected $a$ can only be achieved by the agent's utility-maximizing behaviour. This constraint can be expressed as:

$$\int u(s(x(a, \theta)))g(\theta)d\theta - c(a) \geq \int u(s(x(a', \theta)))g(\theta)d\theta - c(a'), \forall a' \in A \quad (IC)$$

The principal's problem is to select $a$ and $s(x)$ to maximize the expected utility function (P), this choice must satisfy the constraints (IR) and (IC), namely:

$$\max_{a,s(x)} \int (v(\pi(a, \theta)) - s(x(a, \theta)))g(\theta)d\theta$$

s.t. (IR) $\int u(s(x(a, \theta)))g(\theta)d\theta - c(a) \geq \bar{u}$

(IC) $\int u(s(x(a, \theta)))g(\theta)d\theta - c(a) \geq \int u(s(x(a', \theta)))g(\theta)d\theta - c(a'), \forall a' \in A$

3.2.2 Modeling

In the principal-agent relationship, in order to prevent and avoid risks, the introduction of incentive mechanism to design optimal incentive contract is needed, and in addition that using the monitoring mechanism to design the contract is also very important. The implementation of manufacturing service outsourcing is dependent on not only the agent's effort $a$ and the exogenous variable $\theta$, but also the related control measures $s$ of the principal.

Assumed that the output function is linear, that is:

$$\pi = a + \theta \quad (1)$$
The exogenous variable $\theta$ follows the normal distribution and the mean value and standard deviation of 0 and $\delta^2$, where $\delta^2$ reflects the environmental risks of the exogenous variable. The principal's control measure $s$ is related with the agent's efforts, and the linear formula is:

$$s = a + \epsilon$$  \hfill (2)

Where $\epsilon$ follows the normal distribution, and the mean value and standard deviation of 0 and $\lambda^2$. $\lambda^2$ reflects the accuracy of the control measures. $\theta$ and $\epsilon$ are independent of each other, so $Cov(\theta, \epsilon) = 0$.

In the perspective of risk sharing, a fixed revenue contract assumes that the principal is risk neutral and bears all the risk, which it does not need to give a risk premium to the agent, thus the fixed revenue contract is a proposal without incentives. Here we assume that revenue payoff function $y(\pi)$ is linear. When there are control measures, the revenue payoff function of the principal depends on the output $\pi$ and control measures $s$, The revenue payoff function is:

$$y(\pi, s) = F + \beta \pi + \varphi s$$  \hfill (3)

Where $F, \beta, \varphi$ determine the revenue payment scheme, with symbols as $(F, \beta, \varphi)$. Here, $F$ is the fixed revenue for the agent, $\beta$ is the share proportion of the agent ($0 \leq \beta \leq 1$), and $\varphi$ reflects the revenue paid to the agent according to the control signal.

Assume that the agent's effort cost function is: $c(a) = \lambda a^2$, where $\lambda$ is the cost coefficient and $\lambda > 0$, then the actual revenue the agent obtained is:

$$w(a, y) = y(\pi, s) - c(a) = y(\pi, s) - \lambda a^2$$  \hfill (4)

Because the control measures $s$ and the output $b$ is uncertain, the agent's actual revenue $w$ is also uncertain. Taking away the effect of risk factors, the certain revenue of the agent's revenue is equivalent to the difference between the expected revenue and the risk premium, that is $u(a, y) = E(w) – risk premium$

$u$ is the utility function, the risk premium can be regarded as half of the product of the risk aversion $\rho$ and the variance $Var(w)$, so the above equation can be written as:

$$u(a, y) = E(w) - \frac{1}{2} \rho Var(w)$$  \hfill (5)

Assume that the principal is risk neutral, and then the principal’s revenue is:

$$v(a, y) = E(\pi - y(\pi, s))$$  \hfill (6)

For the revenue contract $(F, \beta, \varphi)$ provided by the principal, and according to formula (1), (2), (3) and (4), we obtain the revenue the agent could get from such a contract is:

$$w(F, \beta, \varphi) = F + \beta(a + \theta) + \varphi(a + \epsilon) - \lambda a^2$$  \hfill (7)

According to (4), the certain revenue the agent gets is:

$$u(a, y) = F + (\beta + \varphi)a - \lambda a^2 - \frac{\rho}{2}(\beta^2 \delta^2 + \varphi^2 \gamma^2)$$  \hfill (8)
By equating the first differential of $u$ to zero, \( \frac{\partial u}{\partial a} = \beta + \varphi - 2\lambda a = 0 \), the optimal condition is obtained:

\[
a = \frac{\beta + \varphi}{2\lambda}
\]

(9)

According to the agent’s constraints $u \geq \bar{u}$, and using formula (8), we can get the minimum revenue which is required if the agent is to accept the revenue contract:

\[
F = u - \frac{(\beta + \varphi)^2}{4\lambda} + \frac{\rho(\beta^2 \delta^2 + \varphi^2 \gamma^2)}{2}
\]

(10)

From formula (5), and taking account of formula (1), (2), (8) and (9), we can obtain the principal’s revenue:

\[
v = E(\pi) - E(\gamma(\pi, s)) = (1 - \beta - \varphi)a - F
\]

\[
v = \frac{\beta + \varphi}{2\lambda} - \frac{(\beta + \varphi)^2}{4\lambda} - u - \frac{\rho(\beta^2 \delta^2 + \varphi^2 \gamma^2)}{2}
\]

(11)

In formula (11), \( v \) derivation of \( \beta \) and \( \varphi \), the optimal conditions are obtained:

\[
\frac{\partial v}{\partial \beta} = \frac{1}{2\lambda} - \frac{(\beta + \varphi)}{2\lambda} - \rho \beta \delta^2 = 0 , \text{then} \beta = \frac{1 - \varphi}{1 + 2\lambda \rho \delta^2}
\]

(12)

\[
\frac{\partial v}{\partial \varphi} = \frac{1}{2\lambda} - \frac{(\beta + \varphi)}{2\lambda} - \rho \varphi \gamma^2 = 0 , \text{then} \varphi = \frac{1 - \beta}{1 + 2\lambda \rho \gamma^2}
\]

(13)

And finally we get:

\[
\beta = \frac{\gamma^2}{\delta^2 + \gamma^2 + 2\lambda \rho \gamma^2 \delta^2}, \quad \varphi = \frac{\delta^2}{\delta^2 + \gamma^2 + 2\lambda \rho \gamma^2 \delta^2}
\]

(14)

Now we assume that \( \theta \sim N(0, 1), \epsilon \sim N(1, 2) \) then we know that \( \delta^2 = 1, \gamma^2 = 2, \) the density function of \( \theta \) is:

\[
g(\theta) = \frac{1}{\sqrt{2\pi}} e^{-\theta^2/2}, \theta \in t, \text{the distribution function of} \theta \text{is} G(\theta) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\theta} e^{-x^2/2} dx
\]

then from \( \lambda > 0, \rho > 1, \) we assume that \( \lambda = 0.4, \rho = 3, \) then from the formula (3-14) we can get the result \( \beta = 0.256, \varphi = 0.128, \) it means the principal will share the 25.6% proportion with the agent, meanwhile the principal will also pay the agent 12.8% revenue according to the control signal, thus the principal have two kind of measures to avoid the agent’s moral risk, one way is to encourage with proportion share, the other is supervisory control, then the principal may have a better result by designing the revenue contract containing the incentives and monitoring mechanisms to agent.

3.2.3 Model Analysis

Based on the above model, the conclusions can be drawn as follows:
(1) With the incentives and monitoring mechanisms being incorporated with the design of revenue contracts would cause greater reliance on the information. The principal can take a variety of ways to monitor, if the time to monitor agents is included in the outsourcing time, and then $\beta$ can be understood as revenue paid for output, and $b$ as revenue paid for R & D. With the increased accuracy of control measures, $\gamma^2$ would be smaller, and formula (14) shows that $\varphi$ would be larger. According to formula (12) and (13), when $\varphi$ increases, the share proportion $\beta$ of the output would be reduced, which indicates that with the improvement of the accuracy of monitoring signals, the proportion of revenue paid by the signals would increase. When $\gamma^2$ tends to be 0, that is when the time the agent spends can be almost precisely observed, then $\beta$ tends to be 0, $\varphi$ tends to be 1, and according to formula (3), revenue contracts should be designed on the basis of the information indicated by the monitor signals. Similarly, when $\gamma^2$ tends to $\infty$, that is when no information can be obtained through monitoring, then $\beta$ tends to be 1, $\varphi$ tends to 0, and the design of revenue contracts should be based on the information provided by output. In other cases, the formula (14) indicates how to put these two payments together for the design of revenue contracts. At the same time, according to the formula (12) and (13) we can see, with a increasing, $b$ would be reduced, and vice versa, which indicates that the output share and the monitoring signals are interrelated in the design of revenue contracts.

(2) From $a = \frac{\beta + \varphi}{2\lambda}$ we know, in the manufacturing outsourcing, the agent's effort is unrelated to the fixed revenue paid to it. From the principal's point of view, the fixed revenue paid to the agent would not affect the agent's effort regardless of it is high or low, which indicates that a fixed revenue system does not have the incentive effects for the agent. When $\beta$ and $\varphi$ are 0, $a = 0$, this shows that when the principal neither under incentive system nor under the control system, the agent's effort is zero. This is because there is no incentive to encourage doing better or not, the agent has no motivation to work harder. And without monitoring mechanism means that there is no any pressure to force the agent to work hard. While the fixed payment does not motivate the agent, it does not mean that the design of revenue contracts do not take account of the fixed payment. According to formula (10), only when the agent's fixed payment meets the requirements in formula (10) can the agent accept the payment scheme offered by the principal, otherwise, the principal and the agent can not reach a cooperation contract and thus the principal's outsourcing can not be achieved.

(3) Control measures would have a negative impact on the agent. The introductions of control measures by the principal may result in the effectiveness loss of the agent, which may lead to that the agent refuse to cooperate with the principal. Faced with this situation, the principal may need to compensate the utility loss caused by control measures. For example, the principal could increase the minimum reservation utility or the additional subsidies, thus increasing the attractiveness of the agent, and this may encourage the agent to reveal other information about its efforts, which could prove that it should be rewarded the minimum reservation utility or the additional subsidies, thus fatherly reducing the asymmetric information under the principal-agent situation.

(4) The incentive and control mechanisms influence the agent's efforts. According to $a = \frac{\beta + \varphi}{2\lambda}$ and $\lambda > 0$, if $\beta > 0$ and $\varphi > 0$, both would increase by $a$, which means the output share and control measures both induce or stimulate the agent to work hard. If the principal wants the agent's efforts to achieve a given level, when the company's monitoring is weak, it needs to increase the output share to encourage the agent. In extreme cases, when $\varphi = 0$ (that is, the company does not take control measures), from $a = \frac{\beta + \varphi}{2\lambda}$, we can see inducing the agent to work hard is completely determined by the output share $\beta$. On the contrary, when $\beta = 0$, it is completely determined by the information from monitoring.

4. Conclusions

Producer services outsourcing faces various risks, which needs effective contracts to control. This paper analyzes the kinds of risks in producer services outsourcing, then using the contract concept to construct an incentive and monitoring model, and based on the engineering model, risks control could be achieved.
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