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E-mail: jzus@zju.edu.cn

# Software outsourcing risk management: establishing outsourcee evaluation item systems*

WANG Mei-yuan†[1,2], LU Yao-bin[1], ZHANG Jin-long[1]
([1]School of Management, Huazhong University of Science and Technology, Wuhan 430074, China)
([2]School of Management, South-Central University for Nationalities, Wuhan 430074, China)
†E-mail: annie_31rab@yahoo.com.cn
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**Abstract:** Outsourcing software development has many advantages as well as inevitable risks. Of these risks, outsourcee selection is one of the most important. A wrong outsourcee selection may have severe adverse influence on the expected outcome of the project. We analyzed the risks involved in outsourcee selection and also provided methods to identify these risks. Using the principles of Analytical Hierarchy Process (AHP) and Cluster Analysis based on Group Decision Making, we established an index evaluation system to evaluate and select outsourcees. Real world applications of this system demonstrated its effectiveness in evaluating and selecting qualified outsourcees.

**Key words:** Software outsourcing, Outsourcee evaluation, Group decision making
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## INTRODUCTION

Outsourcing offers several advantages, such as enabling existing staff to concentrate on core competencies, focusing on achieving key strategic objectives, lowering or stabilizing overhead costs, obtaining cost competitiveness over the competition, providing flexibility in responding to market conditions, and reducing investments in high technology. Thus software outsourcing is becoming increasingly popular. However, because of the difference between outsourcers and outsourcees in terms of geography, culture, law, view of value and management methods, there are also disadvantages to outsourcing agreements. These include becoming dependent on an outside supplier for services, failing to realize the purported cost savings from outsourcing, locking into a negative relationship, losing control over critical functions, and lowering the morale of permanent employees (Kliem, 1999). The largest risk comes from the choice of the outsourcees. A wrong choice may make the outsourcer fail to achieve the development scale, time, cost, and quality and benefit goals. The purpose of outsourcing is to pursue potential benefits, but this cannot guarantee that outsourcing will come successful.

Though much research has been done about outsourcing risks, there are few research reports about the evaluation and selection of outsourcees. Section 2 of this paper analyzes various risks resulting from outsourcee selection failure and sums up the major items in evaluating outsourcees' ability. Section 3 discusses the methods to evaluate outsourcee. Section 4 discusses the principle and process of establishing the integrated outourcee ability evaluation item systems. Section 5 provides a practical computation example.

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## ESTABLISHMENT OF OUTSOURCEE ABILITY EVALUATION ITEM SYSTEMS

Software companies have to set up an expert group to evaluate the outsourcee candidate's capacity before making the choice. An inappropriate evaluation process or unsuitable results may bring about outsourcee selection failure, along with the following possible risks: reduced quality of the products delivered by the outsourcees, backward selection and the morality risks (Meng and Su, 2004).

In order to avoid failure in outsourcees selection before making outsourcing decisions, it is necessary to have a risk prevention mindset, to identify various risks from outsourcee during each phase of outsourcing decision, and to establish a scientific efficient outsourcee ability evaluation index system and to select outsourcee scientifically and efficiently. Researchers have proposed the following outsourcee ability evaluation items listed in Table 1.

In accordance with the project outsourcing management requirements and the principle of outsourcee evaluation index system, we summarize the following major five indices for evaluating outsourcee ability after literature research and expert discussion: technology and production ability, management and business ability, reputation, financial operation ability, enterprise environment and understanding of pertinent laws and regulations.

Technology and production ability is an item evaluating the outsourcees' integrated ability in terms of hardware, including outsourcee's technology level, specialized technology investment willingness and ability, IT and telecommunication infrastructure, quality system, enterprise scale.

Management and business ability is an item to evaluate the outsourcee in terms of software, including outsourcees' positioning in the industry sector, knowledge and professionalism of staffs and managers, and employee's training plan.

Reputation is an item used by other customers and consultant agencies to check the outsourcees' reputation, performance, e.g., ability to implement a contract, commercial reputation and verbal recommendation.

Financial operation ability information is obtained through analyzing the audited financial reports and annual audit reports provided by outsourcees. This item is used to check the amount of time the outsourcees have involved in the related business, their market share and fluctuations, and also to evaluate the outsourcees' affordability in specialized technology investments.

Enterprise environment, understanding of pertinent laws and regulations are used to examine the outsourcees' organization environment, understanding of pertinent laws, and regulations, outsourcing business and intellectual property protection practices. The outsourcees' environment influences the establishment of strategic partnership. Particularly with the economic globalization trend, when selecting an outsourcee abroad that has far different political, legal, economical, technical and social culture environments, once the supply chain is established, many unexpected problems may turn up during practical operations. Therefore, this item has a relatively great

**Table 1 Evaluation items analysis**

| Integral items | Items in the literature | Origin of items |
|---|---|---|
| Technology and production ability | Outsourcees' technology level, special technology investment, telecommunication infrastructure, quality system and size | (Jennex and Adelakun, 2003; Quélin and Duhamel, 2003; Jiang *et al.*, 2002; Barki *et al.*, 2001; Lin *et al.*, 2004; Li, 2002; Meng and Su, 2004) |
| Management and business professionalism | Professionalism of outsourcing staff, specialized outsourcing manager, experts and team, knowledge and ability, employee training plan | (Barki *et al.*, 2001; Bahli and Rivard, 2005; Lin *et al.*, 2004; Meng and Su, 2004) |
| Reputation | Performance reputation | (Lin *et al.*, 2004) |
| Financial operation ability | Financial status, cost level, cost and progress plan | (Que, 2003; Lin *et al.*, 2004; Meng and Su, 2004) |
| Enterprise environment, understanding of pertinent laws and regulations | Understanding of pertinent law, regulation, outsourcing, intellectual property protection, organization environment | (Barki *et al.*, 2001; Jennex and Adelakun, 2003; Lin *et al.*, 2004) |

influence. The enterprise environment evaluation includes mainly enterprise culture, geographical location, political, legal and tax policies, and macroeconomic policies.

## METHODS TO EVALUATE OUTSOURCEES' ABILITY

Currently there are several methods to evaluate and select outsourcee either qualitatively or quantitatively. Qualitative methods are suitable for comparison and selection of non-numeric items, while quantitative methods are for understanding the outsourcees' operation system with large amount of data available. For software enterprises, particularly for first time partners, the limitation of information and data makes it necessary to combine both methods. The currently prevalent methods are Analytic Hierarchy Process (AHP), Data Envelopment Analysis (DEA), Fuzzy Synthesis Evaluation (FSE) and Cluster Analysis (CA).

The above mentioned methods all have their advantages and limits. In practice, two or more methods are used together so that the methods can complement one another and yield evaluation procedures and results as scientific, reasonable, and operable as possible. For example, Trlluri and Baker (1996) proposed a two-step partner selection model in which the first step—DEA—is used to distinguish efficient business flow procedures, followed by obtaining solutions using (0-1) integer goal programming and final selection of qualified outsourcee. Meng and Su (2004) recommended an AHP based DEA outsourcee selection model with bias consideration.

There are multi-solutions and uncertainties in evaluating software project outsourcees' abilities, because each item evaluates the outsourcee from different perspective. There are also differences in contribution of each item in evaluating outsourcees' ability. Therefore, a set of objective and fair item's weights is essential in evaluating outsourcees. In practice several pertinent experts form an expert decision group to decide on important problems. Experts come from different technical fields, possessing different bias, knowledge background and understanding views for a specific item, they may have large inconsistency on the same decision problem. In order to eliminate this inconsistency as much as possible and to have a fair, justified, efficient evaluation item system, the paper suggests an integrated method which incorporates AHP and cluster analysis to establish outsourcees' ability evaluation item systems.

## PRINCIPLE AND PROCESS OF ESTABLISHING THE OUTSOURCEE ABILITY EVALUATION ITEM SYSTEMS

AHP is a multi-goal decision method combining qualitative and quantitative analysis which can effectively analyze goal and decision criterion systems, non-sequential relations among hierarchies and comprehensively test the decision maker's judgment and comparison (Peng, 2003). However, it is impossible to take into account each expert's decision preference or bias when several experts are involved in decision making because the integrated evaluation item can only be obtained by calculating the arithmetic mean of each single decision maker's AHP evaluation results, specially when there are a large number of people with consistent opinions but lack of outstanding weights. Cluster Analysis falls into the category of group decision, a multi-variable quantitative analysis method which divides data into several groups with maximum inter-group difference and minimum inner-group difference or a maximum inner-group similarity (Guo, 2004).

This paper suggests an integrated method which incorporates AHP and CA to establish outsourcees' ability evaluation item systems. The principle of this method is: (1) first to obtain each single decision maker's evaluation item weight using AHP; (2) to calculate the vector angles among any two decision makers' decision vectors using group cluster analysis; (3) to merge into groups those decision vectors with angle less than the selected critical angle value, giving higher weights to the larger groups that have higher similarity of judgments among experts, while giving lower weights to the smaller groups; (4) to determine from these results the expert evaluation integrate weight coefficient to scientifically represent the opinions of the majority of the people.

The process of establishing evaluation item systems is:

**Determination of single expert evaluation item weight using AHP**

Suppose $m$ experts are evaluating $n$ evaluating items. The evaluation results of $k$th experts are subjected to AHP calculation and consistency test. The resulted eigenvectors is $\boldsymbol{W}^{(k)}=(w_1,w_2,\ldots,w_n)^{\mathrm{T}}$. Repeat this process until all $m$ experts' eigenvectors are obtained, which is the evaluating item weight of a single expert. See (Wang, 2004) for details on this method.

**Group experts using group decision Cluster Analysis**

Firstly, we should measure the constancy of experts' results. There are many criteria for measuring the constancy. We know the sum of weight coefficient of each expert: $\sum_{i=1}^{n}|w_i|=1$, so we can use the cosine of the angle between two result vectors as the criterion to measure the constancy. Take each expert's evaluation result as a vector, the constancy value of two experts' results are calculated as the cosine of the angle between two result vectors:

$$d_{ij}=\cos\theta_{ij}=\frac{\boldsymbol{W}^i\cdot\boldsymbol{W}^j}{|\boldsymbol{W}^i|\cdot|\boldsymbol{W}^j|}, \tag{1}$$

where, $d_{ij}=d_{ji}$, $\boldsymbol{W}^i$ and $\boldsymbol{W}^j$ represent the evaluation results of expert $i$ and expert $j$ respectively.

Assume critical angle value for clustering is $d_0$, which is the minimum constancy value for the two expert groups to merge into a new cluster. There is no unified standard value $d_0$ which depends on specific problems. In Eq.(1), when consistency value $d_{ij}$ approaches 1, experts $i$ and $j$ have higher similarity in all aspects. Experts $i$ and $j$ can be grouped into one group if their consistency value $d_{ij}$ is more than $d_0$.

Cluster Analysis is carried out as follows:

(1) Suppose $E=\{E_1,E_2,\ldots,E_m\}$ is specialist decision groups and let each cluster represent a single expert, i.e., $G_1=\{E_1\}$, $G_2=\{E_2\}$, $G_3=\{E_3\}$, …, $G_m=\{E_m\}$, with totally $m$ clusters. Let $q=m$;

(2) Calculate consistency value $d_{ij}$ between $m$ clusters using Eq.(1);

(3) Choose the maximum $d_{xy}$, if $d_{xy}>d_0$, let the respective cluster $G_x$, $G_y$ form a new cluster $G_{q+1}=\{G_x, G_y\}$, otherwise go to Step (7);

(4) If $q=2(m-1)$, go to Step (7), otherwise continue to Step (5);

(5) Remove $G_x$ and $G_y$ from cluster sets and add new cluster $G_{q+1}$;

(6) Calculate the consistency value $d_{ij}$ among the clusters in the new cluster set, where $d_{i,q+1}=\max(d_{ix}, d_{iy})$ (Johnson and Wichern, 2001), $i\neq x$ or $y$, $i=1, 2, \ldots, m$. Let $q=q+1$, go to Step (3) and continue to merge the rest of the clusters;

(7) Draw cluster plot and determine clusters and cluster numbers.

**Establishment of integral evaluation weight item systems**

In the above mentioned cluster analysis, $m$ experts are grouped into $t$ clusters ($t\leq m$).

Assume there are $\Phi_k$ experts in the cluster containing the $k$th expert, and the weight of the $k$th expert is $a_k$, $a_k$ is proportional to $\Phi_k$, from expression $\sum_{k=1}^{m}a_k=1$ and $a_1:a_2:\ldots:a_m=\Phi_1:\Phi_2:\ldots:\Phi_m$, we have the weighty coefficient of the $k$th expert: $a_k=\Phi_k\Big/\sum_{i=1}^{m}\Phi_i$ .

The software project outsourcee integral weighted evaluation system $\boldsymbol{W}=(w_1,w_2,\ldots,w_n)^{\mathrm{T}}$ can be obtained from the weighted average of each single expert's evaluation result eigenvector $\boldsymbol{W}^{(k)}=(w_1, w_2,\ldots,w_n)^{\mathrm{T}}$, using weight coefficient $a_k$.

## CALCULATION EXAMPLE

It is necessary to build up an integrated outsourcee ability evaluation item system to choose the most competitive outsourcees from a larger number of similarly qualified candidates. The process of establishing integral evaluation item system is described as follows.

**Calculation of each expert's evaluation item weight using AHP**

First of all, we build a hierarchical structure model including goal layer, decision criterion layer, sub-decision criterion layer. Goal layer $A$ represents outsourcee's ability and goal; decision criterion layer is $B_1$: technology and production ability, $B_2$: management and business professionalism, $B_3$: reputation, $B_4$: financial operation ability, $B_5$: enterprise environment and legal regulation understanding. They are the practical representation of the general goal, and the sub-goals needed to be considered in decision making, they are also the concrete criteria in decision making; sub-decision criterion layers are detailed roll out of the decision criterion layer.

Then, we construct the Pairwise Comparisons Matrix (PCM). The importance of outsourcee evaluation item are determined on the basis of extensive investigations by pertinent experts and personnel within the industry using Delphi method. The PCM $\boldsymbol{A}_{-B}^{(i)}$ is obtained based on large amount of statistical investigation data. For convenience, we just list the experts' evaluation results into 5 groups and only carry out analysis and calculation for goal layer and criterion layer. The PCMs between each pair of decision criterion layer $B_{(i)}$ are as follows:

$$\boldsymbol{A}_{-B}^{(1)}=\begin{bmatrix} 1 & 3 & 4 & 5 & 8 \\ 1/3 & 1 & 3 & 4 & 7 \\ 1/4 & 1/3 & 1 & 5 & 6 \\ 1/5 & 1/4 & 1/5 & 1 & 5 \\ 1/8 & 1/7 & 1/6 & 1/5 & 1 \end{bmatrix};$$

$$\boldsymbol{A}_{-B}^{(2)}=\begin{bmatrix} 1 & 1/3 & 3 & 4 & 8 \\ 3 & 1 & 3 & 5 & 8 \\ 1/3 & 1/4 & 1 & 5 & 6 \\ 1/4 & 1/5 & 1/5 & 1 & 5 \\ 1/7 & 1/8 & 1/6 & 1/5 & 1 \end{bmatrix};$$

$$\boldsymbol{A}_{-B}^{(3)}=\begin{bmatrix} 1 & 2 & 1/3 & 4 & 7 \\ 1/3 & 1 & 1/4 & 5 & 6 \\ 3 & 4 & 1 & 3 & 8 \\ 1/4 & 1/5 & 1/5 & 1 & 5 \\ 1/7 & 1/6 & 1/8 & 1/5 & 1 \end{bmatrix};$$

$$\boldsymbol{A}_{-B}^{(4)}=\begin{bmatrix} 1 & 6 & 3 & 4 & 8 \\ 1/5 & 1 & 1/4 & 1/5 & 4 \\ 1/3 & 4 & 1 & 3 & 7 \\ 1/4 & 5 & 1/3 & 1 & 6 \\ 1/8 & 1/5 & 1/7 & 1/6 & 1 \end{bmatrix};$$

$$\boldsymbol{A}_{-B}^{(5)}=\begin{bmatrix} 1 & 5 & 1/4 & 4 & 1/3 \\ 1/5 & 1 & 1/5 & 5 & 1/4 \\ 3 & 5 & 1 & 8 & 3 \\ 1/6 & 1/5 & 1/8 & 1 & 1/7 \\ 3 & 4 & 1/3 & 7 & 1 \end{bmatrix}.$$

Five expert group eigenvectors $\boldsymbol{W}^{(i)}$ and eigenvalues $\lambda_{\max}^{(i)}$ can be obtained from the above PCM using hierarchy analysis and calculation:

$$\boldsymbol{W}^{(1)}=(0.4524, 0.2534, 0.1744, 0.0865, 0.0332)^{\mathrm{T}},\quad \lambda_{\max}^{(1)}=5.5507;$$

$$\boldsymbol{W}^{(2)}=(0.2672, 0.4322, 0.1834, 0.0850, 0.0332)^{\mathrm{T}},\quad \lambda_{\max}^{(2)}=5.5009;$$

$$\boldsymbol{W}^{(3)}=(0.2403, 0.1923, 0.4339, 0.1005, 0.0330)^{\mathrm{T}},\quad \lambda_{\max}^{(3)}=5.5462;$$

$$\boldsymbol{W}^{(4)}=(0.4646, 0.0762, 0.2527, 0.1724, 0.0341)^{\mathrm{T}},\quad \lambda_{\max}^{(4)}=5.4616;$$

$$\boldsymbol{W}^{(5)}=(0.1722, 0.0892, 0.4377, 0.0359, 0.2650)^{\mathrm{T}},\quad \lambda_{\max}^{(5)}=5.5296.$$

The average random consistency ratio CR of the five PCM were all verified to be less than 0.1, therefore these five PCM $\boldsymbol{A}_{-B}^{(i)}$ have satisfactory consistency.

**Calculation of expert evaluation item weight using Cluster Analysis**

Let $E_1$, $E_2$, $E_3$, $E_4$, $E_5$ represent opinions of five expert groups, divide the five expert groups into five clusters, i.e., $G_1=\{E_1\}$, $G_2=\{E_2\}$, $G_3=\{E_3\}$, $G_4=\{E_4\}$, $G_5=\{E_5\}$. Let $q=5$.

Calculate the consistency value between two expert clusters with $d_0=0.85$, from Eq.(1) we have $d_{12}=0.8909$, $d_{13}=0.8071$, $d_{14}=0.9279$, $d_{15}=0.6204$, $d_{23}=0.7960$, $d_{24}=0.7113$, $d_{25}=0.5873$, $d_{34}=0.8338$, $d_{35}=0.8770$, $d_{45}=0.6894$.

Since $d_{14}=0.9279$ has the maximum value and larger than 0.8500, merge $G_1$ and $G_4$ into a new cluster $G_6=\{G_1, G_4\}=\{E_1, E_4\}$, and the cluster sets become $G_2$, $G_3$, $G_5$, $G_6$.

Calculate the consistency value of the new cluster set to obtain $d_{23}=0.7960$, $d_{25}=0.5873$, $d_{35}=0.8770$, $d_{26}=\max(d_{21}, d_{24})=0.8909$, $d_{36}=\max(d_{31}, d_{34})=0.8338$, $d_{56}=\max(d_{51}, d_{54})=0.6894$, and $q=q+1=6$. Previously, $d_{26}=0.8900$ is the greatest and larger than 0.8500, so merge $G_2$ and $G_6$ into a new cluster $G_7=\{G_6, G_2\}=\{E_1, E_4, E_2\}$, and the new cluster combination becomes $G_3$, $G_5$, $G_7$.

Following the steps of Cluster Analysis, we group the rest of the clusters and obtain the final new cluster $G_8=\{G_3, G_5\}=\{E_3, E_5\}$. Because $d_{78}=0.8340<0.8500$, $G_7$ and $G_8$ cannot be further merged into a cluster.

The results are shown in Cluster Plot, as shown in Fig.1.

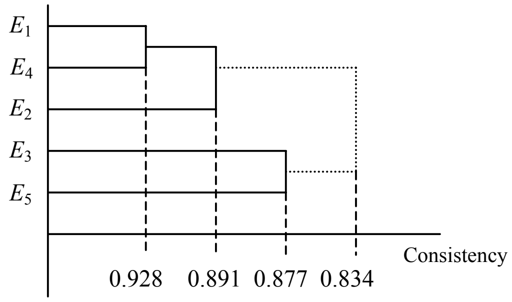


**Fig.1 Cluster Plot**

From the cluster plot, $E_1$, $E_4$, $E_2$ have relatively high similarity, so we group these three expert groups into one cluster, $E_3$, $E_5$ having high similarity and they also fall into one cluster.

Since the expert numbers of each cluster $\Phi_1=\Phi_2=\Phi_4=3$, $\Phi_3=\Phi_5=2$, the weight coefficient of each expert cluster is calculated as:

$$a_1=a_2=a_4=\frac{\Phi_1}{\sum_{k=1}^{5}\Phi_k}=\frac{3}{3+3+3+2+2}=\frac{3}{13},$$

$$a_3=a_5=\frac{2}{13}.$$

Finally, the integrated weight of each evaluation item is obtained from the weighted average of expert clusters evaluation results' eigenvectors:

$$\begin{aligned} w_1&=\sum_{k=1}^{5}a_k\cdot w_1^{(k)}\\ &=\frac{3}{13}\times 0.4524+\frac{3}{13}\times 0.2534+\frac{2}{13}\times 0.2534\\ &\quad+\frac{3}{13}\times 0.4524+\frac{2}{13}\times 0.1744\\ &=0.3331, \end{aligned}$$

$w_2$=0.2191, $w_3$=0.2750, $w_4$=0.1003, $w_5$=0.0688.

The final integrated weights of five evaluation items of expert cluster is $\boldsymbol{W}$=(0.3331, 0.2191, 0.2750, 0.1003, 0.0688)$^{\mathrm{T}}$, which represents: the weight value 0.3331 for technology and production ability, 0.2191 for management and business professionalism, 0.2750 for reputation for financial operation ability and 0.1003 for enterprise environment and legal regulation understanding 0.0688. We see that in software outsourcee evaluation, people put the highest requirement in outsourcees' technology and production ability, reputation and management/business ability, then the financial operation ability and enterprise environment and legal regulation understanding.

## CONCLUSION

Outsourcee evaluation and selection is an important process in software outsourcing work flow. From research we discovered that in software outsourcee evaluation, people put the highest requirement in outsourcee's technology and production ability, reputation and management/business ability, followed by financial operation ability and enterprise environment and legal regulation understanding.

However, the evaluation item weight system is not fixed throughout the evaluation process, it is necessary to make adjustment according to different software projects, countries where outsourcee locates (here or abroad), the relationship between the software company and the outsourcee. Throughout the process of establishing the outsourcee evaluation weight system, such as choosing the item system, evaluating the importance of each item, adjusting the consistency, the evaluation results are to some extent influenced by the subjective opinions of decision makers, experts and users, particularly when we assign the same weight to the expert clusters with more tendency consistency hence neglect the practical existence subtle differences among expert clusters. The influence of this factor on the reliability of evaluation results pends further investigation.

## References

Bahli, B., Rivard, S., 2005. Validating measures of information technology outsourcing risk factors. *Omega*, **33**(2): 175-187. [doi:10.1016/j.omega.2004.04.003]

Barki, H., Rivard, S., Talbot, J., 2001. An integrative contingency model of software project risk management. *Journal of Management Information Systems*, **17**(4): 37-69.

Guo, Z.G., 2004. Social Statistical Analysis Method. China Renmin University Press, Beijing, p.117-140 (in Chinese).

Jennex, M.E., Adelakun, O., 2003. Success factors for offshore information system development. *Journal of Information Technology Cases and Application*, **5**(3):12-31.

Jiang, J.J., Klein, G., Ellis, T.S., 2002. A measure of software development risk. *Project Management Journal*, **33**(3): 30-41.

Johnson, R.A., Wichern, D.W., 2001. Applied Multivariate Statistical Analysis. Tsinghua University Press, Beijing, p.545-589 (in Chinese).

Kliem, R.L., 1999. Managing the risks of outsourcing agreements. *Information Systems Management*, **16**(3): 10580530.

Li, X.M., 2002. Study on "Hold-up" of IT outsourcing. *Journal of Systems Engineering—Theory & Practice*, **3**(3): 26-31 (in Chinese).

Lin, Z.F., Chen, D.Q., Wen, F., 2004. Discussing risk management strategy in IT outsourcing. *Journal of Science*, (2):133-135 (in Chinese).

Meng, G.B., Su, Q., 2004. Research on the management processes of software outsourcing. *Soft Science*, **18**(3):90-93 (in Chinese).

Peng, Y.X., 2003. Management Decision Making Analyses. Science Press, Beijing, p.164-202 (in Chinese).

Quélin, B., Duhamel, F., 2003. Bringing together strategic outsourcing and corporate strategy: outsourcing motives and risks. *European Management Journal*, **21**(5):647-661. [doi:10.1016/S0263-2373(03)00113-0]

Trlluri, S., Baker, R.C., 1996. A Quantitative Framework for Designing Efficient Business Process Alliance. International Conference on Engineering Management and Control (IEMC), p.656-661.

Wang, M.Y., 2004. Building evaluating index system for customer satisfaction index of chain supermarket in view of AHP. *Journal of South-Central University for Nationalities*, **23**(2):96-99 (in Chinese).