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Scheduling the Criteria for Outsourcing Performances by Grey Decision-Making Method: A Case Study of Electronic Industry in Taiwan

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Abstract: The aim of the present study was to construct a systemic model to evaluate the outsourcing activities. This study took an electronic company as a case and then finalized a quantitative decision-making model for business managers to evaluate and manage the outsourcing strategies. Firstly, through the literature review and expert interview the criteria were constructed. Secondly, the Grey Decision-Making was applied to schedule the eventual factors. Finally, the model was organized for business outsourcing management. In the findings, the criteria of Innovation, are the first ranking indices, quality, the second, the customer responsiveness, the third, efficiency, the fourth and integration capability, the fifth. The proposed model constructed from the electronic industry can be also modified to incorporate other outsourcing activities evaluation.

Key words: Scheduling, Grey Decision-Making (GDM), electronic manufacturer

INTRODUCTION

Outsourcing is defined as the purchase of value-creating activities from external suppliers through long-term contracts instead of being previously made internally. By outsourcing activities in which they lack capabilities or they can't create value, firms can concentrate fully on their activities of core competencies.

The main problem in managing outsourcing activities effectively is that companies need to build a suitable evaluation criterion to monitor the process and to push the whole activities towards the best profits^[1-5]. Accordingly, the aim of the present study is to construct the evaluating factors by consulting the relative literatures. Firstly, in order to determine the factors in every aspect, such as strategy, economics, technology, management, costs and etc., we interviewed experts and sought for models for outsourcing objective, estimate index and performance evaluation criterion^[2,4-6]. Secondly, we sought to establish an evaluating structure, suitable for multi-goal and multi-criteria in the electronic industry in Taiwan. Thirdly, we designed and practiced the research methods. Eventually, we constructed a suitable decision-making model with criteria for enterprises to evaluate the outsourcing performance. The objective of this study was as follows: apply the method of Grey Decision-Making to establish a quantitative decision-

making model allowing companies to evaluate outsourcing performance evaluation criteria.

By means of literature review and in-depth expert interviews to analyze these outsourcing activities, we proposed 5 categories (C1~C5) of Performance Evaluation Criteria: efficiency (C1), quality (C2), innovation (C3), customer responsiveness (C4) and integration capability (C5); 5 objectives (O1~O5) of outsourcing activities: share risk of operation (O1), reduce cost of operation (O2), advance contract management capability (O3), greater productivity (O4) and focus on core activities (O5); and 9 items (O11~O13, O21, O31, O41, O42, O51, O52) of evaluation indices on outsourcing activities: supplier commitment (O11), sub-tier relationship and control (O12), financial and material control (O13), performance and results (O21), management systems and planning (O31), manufacturing capability and improvement process (O41), quality systems (O42), support to new product development (O51) and process quality management (O52) and then, we also developed 41 items (O111~O115, O121~O125, O131~O135, O211~O214, O311~O314, O411~O414, O421~O424, O511~O515, O521~O525) of sub-level evaluation indices, such as: continuous improvement (O111), customer satisfaction and support (O112),... etc.

The indices above were verified by the experts; consequently, we constructed the objective analysis for

Construction of Evaluation Model			
1st layer outsourcing target	2nd layer estimate index	3rd layer estimate index	Performance evaluation criterion
Share risk of operations	Supplier commitment	Continuous improvement	Efficiency (C1)
O1	O11	Customer satisfaction and support	Match contract schedule
		Employee involvement and empowerment	C11
		Press improvement approach and tools	Products R & D cycle
		Organization financial healthy	Time
		O111~O115	C12
	Subtier relationships and control	Sourcing Decisions	Employee Productivity
	O12	Rationalized supplier base	C13
		Long-term relationship	Quality (C2)
		Product acceptance	Engineering service quality
		Process control criteria for subtier Selection	C21
		O121~O125	Quality cognition and performance
	Financial and material control	Cost management	C22
	O13	Financial planning	Reliability
		Material resource planning	C23
		Inventory planning and control	Innovation (C3)
		Cost of poor quality control	Striving innovation to reduce cost
		O131~O135	
Reduce cost of operations	Performance and results	Quality performance last year	
O2	O21	Delivery performance last year	C31
		Annual cost productivity	Improvement and responsiveness
		Cost reduction	
		O211~O214	C32
Advance contract	Management systems and planning	Strategic planning	Customer responsiveness (C4)
O3	O31	Customer focus and service	Honest and public
		Human resource plan and training	C41
		Plan of succession and coverage	Contracts' response
		O311~O314	Time
Greater productivity	Manufacturing capability and improvement process	Manufacturing process streamlining and standardization	C42
O4	O41	Process planning	Serviceable (Average repair time)
		Process capability	
		Non-perishable tooling design and control	C43
		O411~O414	Index of competitive
	Quality systems	Internal audit systems	Price
	O42	Non-conforming material and corrective Action	C44
		Quality inspection planning	Flexibility of coordination in non-contract
		Traceability System	C45
		O421~O424	Integration
Focus on core activities	Support to new product development	Integrated design tools	Capability (C5)
O5	O51	Standardization/reuse of tooling and fixture	Integration capability of employee
		Integrated product develop systemically	C51
		Prototype engineering support capability	Teams harmony and spirit of service
		Prototype manufacturing capability	
		O511~O515	
	Process quality management	Process control implementation plan	C52
	O52	Procedure and documentation	
		Control plan	
		Process understanding and control	
		Data collection and analysis	
		O521~O525	

Fig. 1: Multi-target and multi-criteria analysis of outsourcing frame for electronic industry

outsourcing activities (Fig. 1). Then, we adopted the methods of Grey Decision-Making to evaluate these indices in order to develop a suitable decision model regarding on performance evaluation criteria of outsourcing activities.

AN CASE STUDY OF TP ELECTRONIC COMPANY IN TAIWAN

Grey Decision-Making: Grey Decision-Making (GDM) was advanced by Deng^[7]. It differs from conventional

method of probability and statistics. It treats the problems of large uncertainty samples. The theory of Grey System is mainly applied to treat the issues with least data and uncertainty.

According to the GDM, we selected a set of the most effective program (games) from past experiences (events) in order to treat the latest events that need to be resolved. This is so called grey decision and the combination of event and game are situations. The equation is illustrated as follows^[8]:

Situation = (Event, Game): The suitability of a game adopted here is relative to the measurement scale of evaluation and we call it target. Generally, the GDM consists of four factors as follows:

Event: matters need to be deal with.

Game: solutions applied to deal with the matters.

Effect: the effects of solutions toward events.

Target: multi-criteria or multi-scale that is employed to measure the effect.

The fundamental of GDM used in the present research is thus described as below:

We treated the selection of different performance evaluation criteria of suppliers as event. The various alternative programs of performance evaluation criteria were served as game. We took each evaluation index to measure the effect as target and the values of all the performance evaluation criteria on targets under different outsourcing were regarded as effect.

Using the method of GDM, we are able to analyze numerous estimated indices of suppliers before calculating the suitable program of performance evaluation criteria.

Evaluation of each outsourcing program

Effect measure: Due to the different requirements on the targets, there are also different effect measures of targets. Therefore, the effect measure of target depends on the concrete situation. Generally, we adopted upper effect measure, lower effect measure and medium effect measure, described as follows:

Upper effect measure

$$r_{ij} = \frac{u_{ij}}{u_{max}}, u_{max} = \max \max \{u_{ij}\},$$

$$i = 1, 2, 3, \dots, n; \quad j = 1, 2, 3, \dots, m \quad (1)$$

The u_{ij} is the real measure result of situation s_{ij} . The upper effect measure is suitable for the target of the larger, the better target. For example, this research considers the outsourcing targets advance capability of contract management (O3) and greater productivity (O4) as upper effect measure.

Lower effect measure

$$r_{ij} = \frac{u_{min}}{u_{ij}}, u_{min} = \min \min \{u_{ij}\},$$

$$i = 1, 2, 3, \dots, n; \quad j = 1, 2, 3, \dots, m \quad (2)$$

The lower effect measure is suitable for the target of the less, the better.

The targets share risk of operations (O1) and reduce cost of operations(O2) are considered as lower effect measure.

Medium effect measure

$$r_{ij} = \frac{\min \{u_{ij}, u_0\}}{\max \{u_{ij}, u_0\}},$$

$$i = 1, 2, 3, \dots, n; \quad j = 1, 2, 3, \dots, m \quad (3)$$

The u_0 is the designate medium value among the effect sample u_{ij} .

The medium effect measure is suitable for the target of neither large nor little. The target focuses on core activities (O5) belongs to medium effect measure.

By the way of the analysis of effect measure, we directly calculated the effect measure value and didn't need to correct the original measurement, because the Grey Decision-Making was able to provide upper effect measure, lower effect measure and medium effect measure.

The present research used upper measure shown in (1) regarding factor dimensions of advance contract management capability (O3) and greater productivity (O4), as well as, lower measure shown in (2) concerning factor dimensions of share risk of operations (O1) and reduce cost of operations (O2). As to the medium measure, shown in (3), related to the factor dimension of focus on core activities (O5), in which experts decided the most suitable grade serving as medium measure normal weighting. In this case, the best condition was taken for the medium measure.

Since all the performance evaluation indices were qualitative criteria, we took the weightings recognized by experts as the performance value of evaluation programs with regard to the questionnaire results. For example, the measure effect weighting, u_{ij} of continuous improvement

Table 1: Results of evaluation for 1st and 2nd layer factors with the GDM in TP Company

Target	O1	O2	O3	O4	O5	Sum	Grey ranking
C1	0.1620	0.1691	0.1855	0.1860	0.1339	0.8365	4
C2	0.1588	0.1820	0.1723	0.1968	0.1402	0.8501	2
C3	0.1817	0.2018	0.1758	0.1638	0.1436	0.8667	1
C4	0.1636	0.1786	0.1864	0.1755	0.1380	0.8421	3
C5	0.1575	0.1747	0.1844	0.1759	0.1381	0.8346	5

(O111), in the 3rd layer target is: efficiency (C1: 73.33), quality (C2: 88.89), innovation (C3: 80), customer responsiveness (C4: 77.28) and integration capability (C5: 77.78). We took the lower effect measure as $u_{\min} = 73.33$ and used (1) to calculate the effect measure weighting r_{ij} ; thus the results are; Gefficiency (C1: $73.33/73.33 = 1.000$), quality (C2: $73.33/88.89 = 0.825$), innovation (C3: $73.33/80 = 0.917$), customer responsiveness (C4: $73.33/77.28 = 0.949$) and integration capability (C5: $73.33/77.78 = 0.943$). By analogizing the same process, we were also able to have the lower effect measure weighting r_{ij} in the 3rd layer's estimate index.

Multi-target decision matrix: When it exists several targets in evaluating the effects of situations, every target

P corresponds to the decision unit $\frac{r_{ij}^{(p)}}{s_{ij}^{(p)}}$ and the

decision matrix $D^{(p)}$. In the case of multi-target decision, it is regularly to appear that not all of the targets are important equally. As a result, we had to give each target with a corresponding weighting.

The synthetic matrix of multi-target decision is as follows:

$$D^{(\Sigma)} = \left[\frac{r_{ij}^{(\Sigma)}}{s_{ij}^{(\Sigma)}} \right]_{n \times m}, \text{ where, } r_{ij}^{(\Sigma)} = \sum_{p=1}^n r_{ij}^{(p)} \overline{DW}_{ij}^{(p)} \quad (4)$$

Decision criteria: The S_{ij} is derived from $D^{(\Sigma)}$ and we select row decision as below:

$$r_{ij}^{(\Sigma)} = \max r_{ij}^{(\Sigma)} = \max \{r_{i1}^{(\Sigma)}, r_{i2}^{(\Sigma)}, \dots, r_{im}^{(\Sigma)}\} \quad (5)$$

The corresponding s_{ij}^* is the best situation of row.

According to the performance evaluation criteria of outsourcing management, the present study applies the Grey Decision-Making to analyze and evaluate the three layers indices of multi-target decision evaluation. For example, the calculation and weighted effect value of the 1st item (O1) in the 3rd layer $r_{ij} \overline{DW}_{ij}$ includes: efficiency (C1 $1 * 0.0128 = 0.0128$), quality (C2 $0.825 * 0.0128 = 0.0106$), innovation (C3 $0.917 * 0.0128 = 0.0117$),

customer responsiveness (C4 $0.943 * 0.0128 = 0.0121$) and integration capability (C5 $0.943 * 0.0128 = 0.0121$).

Evaluation of multi-targets decision: Before the selection of final program, we should consider all of the weighting with each factor. As a result, we used 4 to calculate weighting. For the convenience of further analysis, we can also use the whole analysis model to evaluate all the weightings. The results are shown as Table 1. Taking the index supplier commitment (O11) corresponding to the criterion efficiency (C1) as an example of calculation. Firstly, we sum up the weighting \overline{DW}_{ij} of supplier commitment (O11), which includes: continuous improvement (O111; 0.0128), customer satisfaction and support (O112; 0.0120), employee involvement and empowerment (O113; 0.0104), process improvement approach and tools (O114; 0.0108) and organization financial healthy (O115; 0.0124); as a result, we obtained the weighting $r_{ij}^{(\Sigma)} = 0.0584$, which is the performance evaluation index of supplier commitment (O11) corresponding to efficiency (C1) shown in Table 1. As the same way, we obtained the weighting $r_{ij}^{(\Sigma)} = 0.0529$, which is the index of subtier relationships and control (O12) corresponding to efficiency (C1 $0.0098 + 0.0116 + 0.0112 + 0.0097 + 0.0106 = 0.0529$) and the weighting $r_{ij}^{(\Sigma)} = 0.0507$, which is the index of financial and material control (O13) corresponding to efficiency (C1 $0.0102 + 0.0107 + 0.0099 + 0.0098 + 0.0101 = 0.0507$). Secondly, we sum up the above- mentioned three weightings to obtain $r_{ij}^{(\Sigma)} = 0.162$, which is the index weighting share risk of operations (O1) corresponding to efficiency (C1 $0.0584 + 0.0529 + 0.0507 = 0.162$). Applying the same process to calculate the rest columns, we obtained the results of index shown as Table 1.

We sum up the index effect measure of efficiency (C1) corresponding to five targets of outsourcing activities [share risk of operation (O1), reduce cost of operation (O2), advance contract management capability (O3), greater productivity (O4) and focus on core activities (O5)] and obtained 0.8365, which is the weighting of integral suitable (Sum -1 $0.162 + 0.1691 + 0.1855 + 0.1860 + 0.1339 = 0.8365$). Using the same process, we obtained the results of all integral suitable alternatives and then, we used row decision shown in the Eq. 1 to obtain the ranking result of GDM analysis.

CONCLUSIONS

1. From the present study, we get the result of sequences for GDM. The categories of innovation and quality are classified as the first and second appraisal.
2. As for the integral suitability of outsourcing activities, the present study pointed out that their innovation is considered the first and quality the second (Fig. 1). Hence, the findings indicate that if an enterprise can put more emphases on striving innovation to reduce cost, improvement and responsiveness, engineering service quality, cognition and performance for quality and reliability, their outsourcing activities could reach a higher degree of integral suitability.
3. In fact, it is necessary to have those five categories of evaluating criteria for outsourcing activities in this case. Because the grades among those categories are similar, it means that we cannot ignore any of them. Besides, it may cause differences, if each category has different goals. Thus, we suggest that firms should adjust outsourcing activities criteria (Fig. 1) and seek for their enough resources to support based on different developing environments.
4. In the process of outsourcing activities, firms often face the problem of how to propose a suitable project in limited resources. The result of the present study provides suggestions for firms that are interested in outsourcing activities. Furthermore, based on this study firms could focus on their characteristics and establish suitable evaluation criteria for outsourcing activities.

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