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Selecting and Evaluating Suppliers by ABC (Activity-Based Costing) Approach

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Abstract: In competitive market now a days, organizations should present high quality and in time products and services for satisfying customers and increasing their market share. Diversity of product and customer needs have the organizations to devolve some of their activities to suppliers so that they can respond their customers needs. The main problem in activity based costing is conducting and controlling these activities. This study deals with supplier selection and determination of order quantity by Activity-Based Costing (ABC) and Total Cost of Ownership (TCO) concept which explain the cost caused by supplier more accurately than traditional cost accounting.

Key words: Supplier, organizations, activity based costing, selecting, model, performance

INTRODUCTION

In most of manufacturing firm the cost of raw materials and component parts constitutes the main cost of a product such that in some cases it can account for up 70%. In circumstances the purchasing department can play a key role in cost reduction and supplier selection is one of the important functions of purchasing management. The supplier selection decisions determine how many and which suppliers should be selected as supply sources and how order quantities should be allocated among the selected suppliers. These supplier selection decisions are complicated due to the fact that various criteria must be considered in the decision making process.

Traditional supplier selection and evaluation methods are all too often based on quoted price which ignore the significant costs associated with ordering, expediting, receiving, inspecting and using purchased parts and materials. A number of alternative approaches for traditional supplier selection methods have been suggested to take these other cost of factors into account. The widely used approach is Weighted Point Plan. This approach uses a simple scoring method which heavily depend on human judgments. The simplest method is the Categorical Method which assigns either good (+) neutral (0) or unsatisfactory (-) to each defined criteria for all suppliers then a total rate for each supplier is calculated (Timmerman, 1986). The Analytical Hierarchy Process (AHP) is other method which uses pairwise comparison and it was applied by Narasimhan (1983).

Recently, Weber and Current (1993), Akinc (1993) Kasilingam and Lee (1996), Ghodsypour and O'Brien (1998) and Karpak (1999) suggested various mathematical programming approaches as mixed integer programming and goal programming which used various supplier performances criteria as quality, delivery, flexibility and so on.

The above methods use various criteria but not consider that how much impact poor performance of supplier and supplied components and materials for the purchaser. In this study we use Activity-Based Costing (ABC) approach and total cost of ownership concept to objectively analyze all costs associated with ordering, expediting, receiving, inspecting and using purchased parts. And we apply a mixed integer programming which use the result of the above ABC analysis to select appropriate suppliers and to determine the order quantities for selected suppliers.

An integrated method for supplier selection: Traditional supplier selection and evaluation methods are all too often based on quoted price which ignore the significant costs associated with ordering, expediting, receiving, inspecting and using purchased parts and materials. These added costs are ignored for many reasons but mainly because of the shortcomings of traditional accounting systems and the performance measures that flow from them.

The costs of acquiring and using the component can also be significant. For example estimates that 50% of a firm's nonconformance costs are caused by the extra work involved in disposing of repairing, scrapping or reworking defective purchased materials. These nonconformance

Table 1: Criteria and performance measures

Criteria	Performance measure
Financial	
Price	Amount of purchased item
Quality	Number of trouble due to quality problem
Delivery	Number (days) of late or early delivery
Non-financial	
Quantity	Number of trouble due to quantity problem
Service and communication	Service and communication problem

costs also include costly schedule change and downtime caused by nonconforming supplies and materials. When all these factors are taken into account, supplier linkages have a greater effect on total cost than the manufacturing process itself.

Traditional manufacturing cost systems, however, track only the purchase price associated with a particular part number or supplier: they bury the cost of ordering, expediting, receiving, inspecting and using purchased goods in factory overhead accounts or general manufacturing expenses by obscuring these additionl costs, accounting systems encourage purchasing managers to select the lowest bidders to avoid unfavorable purchase-price variance, even though the lowest bids may not represent the best overall value in terms of cost, quality and delivery. At the same time, management loses valuable information for evaluating supplier performance.

ABC is a management accounting methodology that aims to assign costs to the activities that generate the costs. TCO focuses on the true costs associated with the entire purchasing cycle thus TCO considers all costs associated with the acquisition, usage, maintenance and follow-up of purchased goods or service not just the purchasing price.

The model presented in this study applies the above ABC methodology and TCO concept to suggest a better and more objective method for suppliers selection and evaluation. In this study, we use both financial and non-financial criteria. While financial criterion is the price, non-financial criteria are quality, delivery, quantity and service and communication. We use performance measures to evaluate the performances of supplier for the criteria in following Table 1.

Activities and cost drivers and other costs analysis: In this study we analyze activities, cost drivers and other costs caused by the poor performance of supplier for the above criteria. For example, a delivered part that does not conform with quality standards causes a production stop, return or rework and so on. The inferior part used should be replaced by the supplier when delivering the next order. The results of this analysis are given in Table 2. But it is possible that each purchaser has different activities, cost drivers and other costs. For this reason we suggest the most general activities, cost drivers and other costs.

Table 2: Activities, cost drivers and costs caused by poor performances of supplier

Performance criteria/activity/cost driver	Costs caused by poor performance
Quality problem	
Return or rework	Cost of carrying excess
Rescheduling or planning	Inventory due to their unreliability
Reordering	
Repackaging	Cost of train supplier in quality
Rereceiving	methods
Additional inspection	
Production stopping (set-up)	Lost sales
Disposing of scrap	
Delivery	
Late	
Followup or expediting activity	Lost sales
Rescheduling or planning	Cost of carrying extra inventory
Premium transportation	
Production stopping	
Early	
Holding and administrative activity	Inventory holding cost
Quantity problem	
Additional reception	Lost sales
Additional setup	
Rescheduling and planning	
Additional inspection	
Reordering	
Service and communication problem	
Information exchangeability response to	Cost of delays due to slow problem

MATERIALS AND METHODS

A mixed integer programming model: Based on the above activity analysis, the supplier selection problem can be formulated as the following mixed integer programming model.

$$\sum_{i=0}^{I}\sum_{j=1}^{J} P_{ij}X_{ij} + \sum_{n=1}^{5}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K} Y_{ij}F_{nij}A^{1}_{njik} +$$

$$\sum_{n=1}^{5}\sum_{i=1}^{I}\sum_{j=1}^{M}\sum_{k=1}^{J} Y_{ij}F_{nij}D_{nijm}A^{2}_{nijm} +$$

$$\sum_{n=1}^{5}\sum_{i=1}^{I}\sum_{j=1}^{J} C_{nij}Y_{ij} + \sum_{j=1}^{J} Z_{j}S_{J}$$

S.t:

$$\sum_{j=1}^{J} X_{ij} \geq Q_{i} \quad \text{For } i = 1,2,3,.....,I \qquad (1)$$

$$\sum_{j=1}^{J} Y_{ij} \geq 1 \quad \text{For } i = 1, 2, 3, ..., I \qquad (2)$$

$$X_{ij} < V_{ij} \quad \text{For } i=1,2,3,\ldots..,I,\ j=1,2,3,\ldots,J \tag{3}$$

$$X_{ij} < MV_{ij} \quad \text{For } i=1,2,3,\ldots..,I,\ j=1,2,3,\ldots,J \tag{4}$$

$$\sum_{j=1}^{J} Y_{ij} \leq MZ_{j} \quad \text{For } i=1,2,3,\ldots..,J \tag{5}$$

$$\sum_{j=1}^{J} Y_{ij} \leq w_{i} \quad \text{For } i=1,2,3,\ldots..,J \tag{6}$$

$$\sum_{j=1}^{I} Z_{j} \leq W \quad \text{For } i=1,2,3,\ldots..,J \tag{7}$$

$$X_{ij} > 0 \quad \text{For } i=1,2,3,\ldots,I,\ j=1,2,3,\ldots,J \tag{8}$$

$$Y_{ij} = 0 \text{ or } 1 \quad \text{For } i=1,2,3,\ldots,I,\ j=1,2,3,\ldots,J \tag{9}$$

$$Z_{j} = 0 \text{ or } 1 \quad \text{For } i=1,2,3,\ldots,I,\ j=1,2,3,\ldots,J \tag{10}$$

Where:

- i, j = i is the item index (i =1, 2, 3, ..., I)
- j = Supplier index (j =1, 2, 3, ..., J)
- n = Criteria index (1: quality, 2: late delivery, 3: early delivery, 4: quantity, 5: service)
- k, m = k and m are activity 1, 2 index (k =1, 2, 3, ..., K) (m = 1, 2, 3, ..., M)
- P_{ij} = Price of item i from supplier j
- F_{nij} = The quantity of performance measure of criterion n for the item i from supplier j
- Q_i, V_{ij} = Q_i is demand for the item I
- V_{ij} = Supply capacity of supplier j for the item i
- X_{ij} = Order quantity of supplier j for the item i
- Y_{ij} = 1, if supplier j is selected for supplying item i, 0, otherwise
- Z_j = 1 if supplier j is used at all, 0 otherwise
- A_{nijk}^{1} = The cost of activity k caused by performance n of supplier j for the item I (Superscript "1" means activity 1 is an activity that uses performancemeasure as a cost driver)
- A_{nijm}^{2} = The cost of activity m caused by performance n of supplier j for the item I (Superscript "2" means activity 2 is an activity that does not useperformance measure but others as a cost driver)
- D_{nijm} = The cost driver of activity m caused by performance n of supplier j for the item i
- C_{nij} = The other cost caused by performance n of supplier j for the item i
- S_j = Supplier j sustaining cost
- w_i = The maximum number of supplier for item i
- W = The maximum number of supplier

The objective is to minimize the sum of purchasing cost and additional activities costs causedby supplier, other costs and supplier sustaining cost. Additional activities costs consist of twocosts term. The first is costs of activities use performance measure as cost driver and the secondis not. Supplier sustaining costs are associated with a given supplier that are independent of thequantity and include maintaining files on supplier characteristics and performance and periodicevaluations of supplier performance.

Equation 1 represents the demand constraint for each item. Equation 2 requires that all itemsbe supplied. The capacity of items from various suppliers is modeled in Eq. 3. Equation 4 represent a supplier is selected before orders are placed Eq. 5 require items to be supplied only from the selected suppliers. The maximum number of suppliers to be employed for each item is represented by Eq. 6. Equation 7 represents the maximum number of suppliers to be employed. The non-negativity and integrality restrictions are represented by Eq. 8-10.

Supplier's performance evaluation: In the previous study we use various factors to select appropriate suppliers and order quantities. Because the values of these factors are estimated to compute the degree of impacts from poor performances of supplier the values of these factors are different from the actual values.

In this study we analyze the variances between the estimated and the actual value. There are several advantages to analyze the variances with ABC and TCO concept, not only for the purchaser but also for the supplier. For the purchaser the ABC and TCO allow to identify the relative importance of the different cost components and to give the useful information about cost reduction.

That is the purchaser may attempt to influence estimated units of cost drivers by reducing or eliminating some of the activities. For the supplier it provides an objective indication about the degree of affection that caused by herown poor performances for the various criteria and the importance of the different criteria involvedin the supplying process.

For example, in we present cost driver rate variance and cost driver frequency variance of quality performance for item i. The cost driver rate variance refers to factors that allow the purchaser to improve its efficiency by reducing its cost driver rates. The purchaser is responsible for this variance. The Cost Driver frequency variance refers to the difference actual and estimated use of cost drivers (performance measure) for which the supplier is responsible since he can potentially affect the cost drivers.

The variances of quality performance for item i
Cost driver rate variance:

$$ACD = (ACDR - SCDR)$$

$$\sum_{j\in T_i} F_{ij}^{A}\left(\sum_{k} A_{1ijk}^{1A} - \sum_{k} A_{1ijk}^{1}\right) + \sum_{m}\sum_{j\in T_i} F_{ij}^{A} D_{ijm}^{A}\left(A_{1ijm}^{2A} - A_{1ijm}^{2}\right)$$

Cost driver frequency variance:

$$SCDR = (ACD\text{-}SCD)$$

$$\sum_{j\in T_i}\sum_{k} A_{1ijk}^{1}\left(F_{ij}^{A} - F_{ij}\right) + \sum_{m}\sum_{j\in T_i} A_{1ijm}^{2}\left(F_{ij}^{A} D_{ijm}^{A} - F_{ij} D_{ijm}\right)$$

Where:

A = Actual
S = Estimated standard
CD = A number of cost driver
CDR = Cost driver rate
iT = A set of suppliers for item i

Together with the above variance analysis we can evaluate the supplier's performance by calculating the rate of suppliers for each criterion which can be used to reflect supplier's performance in next purchasing decisions. A Supplier Rating Index (SRI) for the supplier performance is calculated as follow:

$$SRI = 1 + \frac{(\text{Actualactivity cost} - \text{Estimated standard activity cost})}{\text{Estimated standard activity cost for supplier}}$$

Then, we can modify the objective function as follow considering this SRI:

$$\sum_{i=1}^{I}\sum_{j=1}^{J} P_{ij} X_{ij} + \sum_{n=1}^{5}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K} Y_{ij} F_{nij} A_{njik}^{1} SRI_{nij} +$$

$$\sum_{n=1}^{5}\sum_{i=1}^{I}\sum_{m=1}^{M}\sum_{j=1}^{J} Y_{ij} F_{ij} D_{nijm} A_{njim}^{2} SRI_{nij} +$$

$$\sum_{n=1}^{5}\sum_{i=1}^{I}\sum_{j=1}^{J} C_{nij} Y_{ij} + \sum_{j=1}^{J} Z_j S_J$$

RESULTS AND DISCUSSION

A numerical example: An example problem with solutions is presented in this study to illustrate the model for supplier selection. The demand for the three items and the selling pric es and capacities of suppliers for the three items and the supplier sustaining cost for the four suppliers are given in Table 3. The supplier performance associated with the criteria for the three items are given in Table 4. Table 5 other cost caused by poor performance Table 6 represents activities costs. The results are summarized in Table 7 and the variances are summarized in Table 8.

In Table 8, because of better performances of suppliers the total variance is "favorable" for item 1 and because of the efforts of cost reduction of purchaser and bette r performances of suppliers the total variance is "favorable" for item 2 and cost driver rate variance of item 3 is "unfavorable" by reasons of inefficiency of purchaser. Table 9 represents the SRI of each supplier for item.

Table 3: Price, capacity, demand for item i and supplier sustaining cost

	Item 1		Item 2		Item 3		
Suppliers	Price($)	Capacity	Price($)	Capacity	Price($)	Capacity	Sustaining cost($)
1	10	300	8	300			14
2	8	310	7	230	9	250	9
3	9	270			14	270	16
4			7	280	8	300	16
Total demand	500		550		500		

Table 4: Estimated standard (actual) supplier performance for item i

	Supplier 1		Supplier 2			Supplier 3		Supplier 4	
Performance	Item 1	Item 2	Item 1	Item 2	Item 3	Item 1	Item 3	Item 2	Item 2
F_1	3 (5*)	9 (10)	18 (15)	4	15 (12)	18	4	5 (5)	12 (12)
F_2	17 (15)	12 (8)	2 (2)	6	16 (15)	3	14	7 (8)	13 (15)
F_3	8 (5)	7 (7)	17 (16)	9	5 (7)	11	18	6 (4)	14 (15)
F_4	15 (12)	14 (13)	13 (13)	7	4 (6)	19	9	13 (13)	10 (10)
F_5	2 (5)	5 (3)	4 (6)	6	6 (3)	3	6	1 (1)	3 (3)

*Actual

Table 5: Other cost caused by poor performance

Costs (unit: $)	Item 2	Item 2	Item 3
C_1	15	26	25
C_2	18	16	17
C_3	21	14	19
C_4	31	26	23
C_5	24	15	29

Table 6: Estimated standard (actual) activities costs caused by poor performance of supplier for item i

Activities	Supplier 1		Supplier 2			Supplier 3		Supplier 4	
(unit: $)	Item 1	Item 2	Item 1	Item 2	Item 3	Item 1	Item 3	Item 2	Item 3
A_{1k}^1									
k = 1	20 (18*)	26(22)	27 (22)	9	7 (7)	12	12	16 (16)	10 (10)
2	24 (22)	14 (14)	19 (20)	19	8 (8)	28	13	12 (12)	9 (6)
3	15 (19)	15 (15)	22 (20)	22	8 (17)	14	8	21 (20)	7 (7)
A_{1m}^2									
m = 1	19 (19)	23 (23)	12 (14)	19	12 (12)	18	19	27 (25)	5 (20)
2	26 (29)	22 (20)	15 (18)	26	15 (15)	16	28	21 (21)	19 (19)
A_{2k}^1									
k = 1	3 (5)	7 (7)	11 (10)	7	11 (11)	10	6	7 (7)	9 (11)
2	12 (14)	11 (15)	14 (19)	10	11 (9)	8	9	11 (11)	10 (10)
A_{2m}^2									
m = 1	12 (12)	13 (13)	22 (20)	15	7 (7)	17	8	13 (13)	7 (9)
2	19 (20)	17 (12)	9 (10)	18	5 (8)	18	7	8 (8)	4 (6)
A_{3k}^1									
k = 1	12 (10)	20 (20)	12 (11)	28	9 (9)	7	13	22 (22)	13 (13)
2	9 (10)	17 (17)	17 (13)	24	1110 ()	12	13	26 (30)	10 (15)
A_{3m}^2									
m = 1	16 (15)	13 (10)	14 (13)	16	14 (14)	16	19	11 (8)	10 (10)
2	15 (11)	15 (15)	21 (18)	13	20 (20)	11	12	15 (11)	10 (15)
A_{4k}^1									
k = 1	11 (10)	19 (19)	8 (10)	19	12 (12)	7	7	25 (29)	13 (11)
2	5 (10)	13 (13)	7 (11)	28	4 (4)	7	5	14 (14)	3 (3)
A_{4k}^2									
m = 1	8 (10)	18 (18)	15 (17)	14	11 (11)	8	9	18 (17)	11 (11)
2	14 (13)	22 (20)	12 (15)	12	13 (13)	21	15	20 (20)	17 (17)
A_{4m}^2									
k = 1	17 (20)	20 (23)	13 (15)	7	21 (27)	29	13	17 (26)	15 (15)
2	22 (20)	16 (16)	18 (15)	17	23 (23)	24	7	17 (17)	20 (24)
1	22 (22)	16 (16)	15 (15)	17	7 (7)	22	11	21 (21)	7 (7)
A_k^2									
k = 1	11 (10)	19 (19)	8 (10)	19	12 (12)	7	7	25 (29)	13 (11)
2	5 (10)	13 (13)	7 (11)	28	4 (4)	7	5	14 (14)	3 (3)
m = 1	8 (10)	18 (18)	15 (17)	14	11 (11)	8	9	18 (17)	11 (11)
2	14 (13)	22 (20)	12 (15)	12	13 (13)	21	15	20 (20)	17 (17)
A_{5m}^2									
k = 1	17 (20)	20 (23)	13 (15)	7	21 (27)	29	13	17 (26)	15 (15)
2	22 (20)	16 (16)	18 (15)	17	23 (23)	24	7	17 (17)	20 (24)
	1	22 (22)	16 (16)	15 (15)	17	7 (7)	22	11	21 (21)
	7 (7)								

(* is actual activity cost)

Table 7: Results of example problem

Supplier (unit:$)	Item 1	Item 2	Item 3
1	190	270	-
2	310	-	200
3	-	-	-
4	-	280	230

Table 8: The variances

Variables	Item 1		Item 2		Item 3	
(unit: $)	CDR Var.	CDR Var.	CDR Var.	CDR Var.	CDR Var.	CDR Var.
Quality delivery	30 U	75 F	85 F	123 U	48 F	186 F
Late	77 U	116 F	8 F	192 F	135 U	33 U
Early	174 F	220 F	33 F	148 F	143 U	151 U
Quantity	230 U	156 F	13 F	94 F	82 U	4 U
Service	1 F	171 U	18 U	104 F	30 U	153 F
Total Var.	162 U	396 F	121 F	415 F	342 U	151 F
	234 F		536 F		191 U	

(F: Favorable, U: Unfavorable)

Table 9: The SRI of supplier for item

Performances	Supplier 1		Supplier 2		Supplier 3	
	I1	I2	I1	I3	I2	I3
F_1	1.107	1.057	0.841	0.916	0.959	0.863
F_2	0.958	0.656	1.013	0.960	1.142	1.403
F_3	0.552	0.954	0.809	1.374	0.639	1.320
F_4	0.862	0.889	1.259	1.500	1.030	0.967
F_5	1.868	0.635	1.107	0.559	1.164	1.095

CONCLUSION

In this study, we proposed an activity-based costing approach and Total Cost of Ownership concept to objectively analyze all costs associated with supplier and supplier components and materials. And we apply a mixed integer programming which use the result of the above analysis to select appropriate suppliers and to determine order quantities for selected supplier.

The proposed method will help to make better supplier selection decision resulting in decreased overall costs. Own approach will give the purchaser useful information for possible cost reduction and give an objective indication about the degree of affection that caused by own poor performances for the various criteria.

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