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Manufacturing Outsourcing Decision-making based on Screening Core Activities and Fuzzy Multi-criteria Approach

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Abstract: Today, outsourcing is an important strategic issue for organizations such as private and public. Accordingly, a significant question faced to organizations that is what functions (activities) should perform in-house and which ones should buy from outside suppliers? The answers to these questions are known as make-or-buy decisions. Literature review shows that has been emphasized on multi-criteria nature of make-or-buy problem but little attention has been to mathematical modeling. Moreover, absence or hard access to reliable data in real environments is important problem that needs to attention. Beside to authors believe that a single-stage (single-phase) framework is not useful for decision-making outsourcing. In this study, a outsourcing decision-making framework for the manufacturing activities is presented. This framework supports managers of the manufacturing firms confronted with the choice of whether activity to maintain (perform) internally, or to outsource. The framework is based on two phases. In first phase, the considered activity has been checked from core (or non-core) aspect. For non-core activity, phase 2 was accomplished. This phase contains the proposed criteria (and measures) for the outsourcing decision-making and a model based on a fuzzy TOPSIS approach. The framework is applied in a real case application.

Key words: Make-or-buy, outsourcing, two-phase, core, TOPSIS

INTRODUCTION

Today, outsourcing is an important strategic issue for organizations such as private and public. Organizations expect to attain different benefits through successful outsourcing; however there are some risks that may be realized if outsourcing is not managed appropriate (Kremic *et al*., 2006). Organizations may outsource some functions or activities they used to perform themselves or which are new functions (or activities).

In this respect, a significant question faced to organizations that is what functions (activities) should perform in-house and which ones should buy from outside suppliers? The answers to these questions are known as make-or-buy decisions.

These decisions are very important for organizations. Although, the outsourcing strategies of many organizations don't remain constant over time. So, make-or-buy decisions must be reconsider in order to support the firm's new strategies. In other words, markets, demand, or governmental policies may be changed over time and consequently, influenced business strategies of the firms. Therefore, outsourcing strategies must be co-ordinated with these changes (Canez *et al*., 2000; Fine and Whitney, 1996; Probert *et al*., 2001, Perrons, 2004).

The make-or-buy decisions issue has partly long history. Based on statement's Mclvor and Humphreys (2000), the conceptual foundation for the make or buy decision is Williamson's theory (transaction cost analysis). Although, considering the strategic issues caused a evolution in the context of the make-or-buy decisions (Mclvor *et al*., 1997; Canez *et al*., 2000). Leong *et al*. (1990) considered five areas as competitive priorities: quality, delivery performance, cost, flexibility and innovativeness. They believed that manufacturing strategies should be developed based on conditions of these priorities.

Some studies in literature of make-or-buy decision-making (mobdm), such as Venkatesan (1992), Mclvor *et al*. (1997) and Cox (1997) analysed mobdm from resource-based view (where the decision is taken by concentrated on the firm's resources).

Also, some works, like Venkatesan (1992) and Mclvor *et al*. (1997) is founded on identifying strategic modules (in the products) or core activities (in general). Therefore, the outsourcing strategy is retaining core activities (strategic modules) and outsourcing non-strategic modules (sub-assemblies, parts) or non-core functions (activities).

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From other viewpoint, some studies like Welch and Nayak (1992) and Probert (1997) viewed mobdm from technological aspect. Welch and Nayak (1992) considered three factors maturity level of process technology, competitors's process technology position and importance of process technology in a decision matrix as named strategic sourcing model.

Quinn and Hilmer (1994), proposed core competency and strategic vulnerability as the mobdm criteria. Fine and Whitney (1996) presented three factors consists of capability, manufacturing competitiveness and technology.

Jennings (1997) provided a framework for evaluating the outsourcing decisions contained a set of strategic guidelines based on areas: business environment, cost, supplier relationships, technology and capability. Fill and Visser (2000) presented a conceptual framework for mobdm consists of contextual factors, strategy and structure and transaction costs and Mclvor and Humphreys (2000) discussed a computer-based system based on case-based reasoning for make-or-buy decisions.

Insinga and Michael (2000) applied potential for an activity for yield competitive advantage and Internal capability to perform an activity in comparison with competitors in a two-dimensional decision matrix.

Canez *et al*. (2000) and Platt *et al*. (2002) applied technology and manufacturing processes, cost, supply chain management and logistics and support systems as influencing areas in mobdm and developed the set of criteria related to each area.

Pandey and Bansal (2004) considered criticality, stability and simplicity as the factors for selecting activities to outsource (IT Outsourcing environment).

Henny van de and van Peet (2006) inspiration from Canez *et al*. (2000) and Platt *et al*. (2002) developed their studies and applied engineering and RandD, human resources, financial, supply chain management and logistics, support systems and technology and manufacturing as the areas for outsourcing decision-making.

Kremic *et al*. (2006) proposed strategy, cost, function characteristics and environment as factors which may impact outsourcing decisions.

Mantel *et al*. (2006) applied criteria which had been developed by Quinn and Hilmer (1994) by developing operational sub-criteria.

Wang and Yang (2007) discussed six factors economic, resource, strategy, risk, management and quality for information systems outsourcing decision-making.

Chupra and Meindl (2007) considered demand scale, demand uncertainty and specifity of assets as the factors influencing propency to outsource and Hwang *et al*. (2007) applied manufacturing technology, outsourcing risk and managerial, financial and operational issues as the items for evaluation of a make-or-buy decision-making problem.

As can be seen, in make-or-buy decisions literature, various criteria are proposed with different authors. Moreover, many models and frameworks have been developed to this purpose; however, many of them were concentrated on identifying sourcing strategy based on conceptual frameworks or qualitative models (Insinga and Michael, 2000; Quinn and Hilmer, 1994; Welch and Nayak, 1992). It would be better to say there are seldom works which were contained the methodologies for unequivocal decision-making between in-house performing and outsourcing alternative (Platt *et al*., 2002).

In analysis of mobdm's literature, can be said that generally, many managers expect to gain more accurate and clear results (material) for their final decisions. The important point in earlier works is that in these works, little attention has been to mathematical modeling. In other words, in many works of literature, two or three-dimensional matrices (Welch and Nayak, 1992; Insinga and Michael, 2000) or decision-making algorithms (Tayles and Colin, 2001) more than mathematical models can be seen.

As also in the articles and studies of recent years has been shown, regarding to the complexity and nature of outsourcing decision-making, this problem can be considered as a multi-criteria problem (Canez *et al*., 2000; Platt *et al*., 2002; Mantel *et al*., 2006; Henny van de and van Peet, 2006; Hwang *et al*., 2007; Wang and Yang, 2007). So, perhaps can be expressed that using two or three-dimensional matrices and decision-making algorithms can not be useful to solving this problem and therefore, utilization of mathematical models (especially, multi-criteria decision-making models) can be more helpful. Using mathematical techniques (in particular, multi-criteria techniques) can be helpful for increasing accuracy and speed of decision-making process.

The other point is lacking appropriate access to reliable data in real environments. So, generally refer to the viewpoints and Judgements of experts based on linguistic variables and fuzzy numbers can be a good solution to this deficit.

Moreover, because the importance of the firm`s core activities, this article's authors believe that a single-stage (single-phase) framework is not useful for decision-making outsourcing.

In this study, to resolve these shortcomings, a decision-making framework based on two-phase is proposed. the first phase is devoted to identification and screening the core activities and the second phase contains the decision-making model based on using TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) as a multi-criteria technique and application of the fuzzy set theory. Also, proposed framework for real data (in a advising manufacturing firm) is performed and the gained results by the experts and cross-functional team members (that was convened to judge and make outsourcing decision in the firm) is approved.

THE DECISION-MAKING FRAMEWORK

Phase 1: In first phase of developed framework, must be identified that the activity under consider is core or non-core? Because sustaining the competitive advantages, the core activities must be performed in-house. Mclvor *et al*. (1997) defined core activity as is central to the company successfully serving the needs of potential customers in each market. Arnold (2000) defined core activities such that all activities which are necessarily linked to the firm's existence. Arnold (2000) called these activities as the company's core.

Mclvor *et al*. (1997) believed that distinguishing between core and non-core activities is a difficult task and it needs to sufficient accuracy. The guidelines for identifying core activities (and examples of these activities) should be developed by top management.

If the activity was core, rationally, this must be performed inside the firm (Venkatesan, 1992; Mclvor *et al*., 1997); but, the logical question is that are firm's capability and capacity sufficient?

If the firm's capability and capacity were not enough, the firm must be enhance them. These enhancement may be realized by research and development and other investments such as purchasing new equipments, technology acquisition from outside of the firm and so on.

Phase 2: If considered activity was not core, should be referred to second phase. In phase 2, a fuzzy multi-criteria decision-making model based on TOPSIS technique (Technique for Order Preference by Similarity to Ideal Solution) and application of the fuzzy set theory has developed.

The decision-making criteria (or factors) may be changed from a range of candidate activities to others; for example, the decision-making criteria of RandD (Research and Development) activities may be differed from manufacturing activities. In this article have been concentrated on manufacturing activities and hence, proposed decision-making criteria have been developed related to manufacturing conditions. On the other hand, the considered alternaties in this article consist of performing activity in-house or internally and outsourcing.

In this phase, the criteria have been developed in two categories:

- Strategic criteria
- Economic criteria

In strategic criteria, four criteria core competency, information risk and ability and in economic criteria, only total cost have been considered.

The proposed criteria in this article based on both conditions of real production environments and review of proposed criteria in previous works, especially Quinn and Hilmer (1994) and Mantel *et al*. (2006) and also, Fine and Whitney (1996) that was expressed two dimensions of dependency to suppliers (knowledge and capacity) are developed. Also Tayles and Colin (2001) hint to capability and capacity. In this article, these factors called to gather as ability.

Although, in first phase, the core activities have been screened but it may be exist the traces or vestiges of firm's core competency in activities which have been came to second phase. So, in phase 2, the risk of core competency damage (lose) has been noticed. As Arnold (2000) cited, core competencies have three characteristics:

- Differentiation between the company and its competitors
- Impossible to imitate by competitors over time
- Usable for multiple purpose

Each resources with these characteristics are core competencies and should remain within a company and should not be outsourced.

In addition to core competencies, can not be passed easily from significance of the firm`s key information. Often, because dissemination of some information like the information of firm's new technologies or products in hand (under working) and disclosure them for the competitors, future of firm's competitive position may be faced to serious risks. Therefore, risk of information dissemination should be consider about each nominated activity which has been acceded to phase 2.

Another important condition to perform each activity is existing of enough capability determine whether the firm has the capability to perform the activity (process). Also, the next question is that do it have enough capacity? Tayles and Colin (2001) defined that capacity is about the availability of resources include labour, capital, plant and

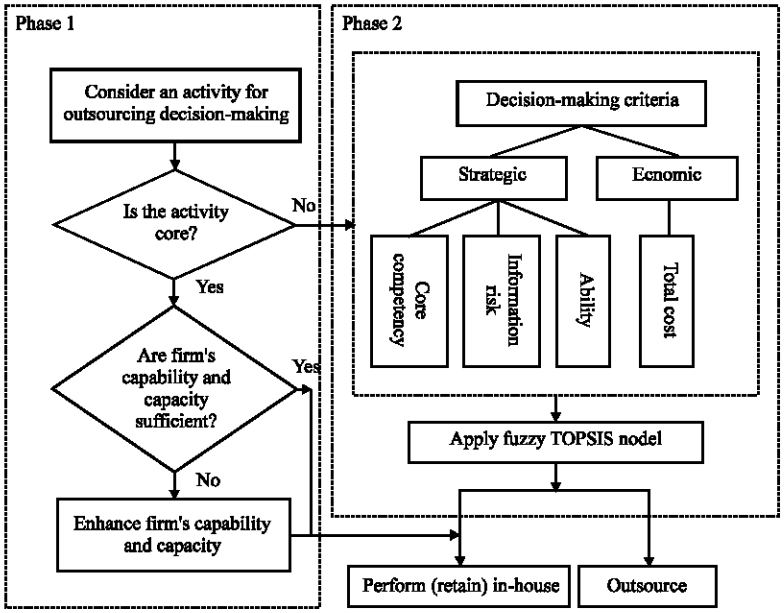

Fig. 1: The proposed framework for outsourcing decision-making

Table 1: Criteria, sub-criteria and related measures of phase 2

Measure	Sub-criterion	Criterion
Risk of core competency damage	Core competency	Strategic considerations
Risk of (important) information lose	Information risk	
Capability Capacity	Ability	
Total cost of activity realization	Total cost	Economic considerations

equipment time. In this study, sum of capability and capacity has been called ability. Beside to strategic criteria, the total cost of activity performing has been considered as the measure of the economic criteria which used in phase 2. Criteria and sub-criteria are shown in Fig. 1 and the measures of (sub)criteria are shown in Table 1.

The decision-making model based on fuzzy TOPSIS: The technique used here is TOPSIS technique (Technique for Order Preference by Similarity to Ideal Solution); Generally, the numerical data (related to quantitative factors) may be not available carefully and also, data of qualitative factors should be asked from experts in the form of linguistic variables. So, moreover TOPSIS as decision-making technique, fuzzy sets theory were utilized. In order to attain technical principles of fuzzy TOPSIS, the study of Bottani and Rizzi (2006) has been used. The steps of the decision-making model are:

- To determine the relative importance (or weight) of factors by paired comparison
- To determine the level of each factor for both two alternatives in the form of linguistic judgements
- To transform expert opinions (linguistic judgements) to fuzzy triangular numbers and to establish the initial numerical matrix
- To normalize the numerical data and to establish the weighted matrix. In order to attain normalized data bottom equations (Bottani and Rizzi, 2006) were applied:

$$r_{ij} = \frac{x_{ij}}{u_j^+} = \left(\frac{l_{ij}}{u_j^+}, \frac{m_{ij}}{u_j^+}, \frac{u_{ij}}{u_j^+}\right), \quad j \in \text{Benefit} \quad u_j^+ = \max(u_{ij}), \forall i = 1,2,...,m,..., j \in B \tag{1}$$

$$r_{ij} = \frac{l_j^-}{x_{ij}} = \left(\frac{l_j^-}{u_{ij}}, \frac{l_j^-}{m_{ij}}, \frac{l_j^-}{l_{ij}}\right), \quad j \in \text{Cost} \quad l_j^- = \min(l_{ij}), \forall i = 1,2,...,m,..., j \in C \tag{2}$$

To calculate the distances of the alternatives (in-house and outsourcing) from ideal values by below equations (Bottani and Rizzi, 2006):

$$d_{i^*} = \sum_{j=1}^{n} d\left(v_{ij}, v_j^*\right) = \sum_{j=1}^{n} \sqrt{\frac{1}{3}\left[\left(l_{ij} - l_j^*\right) + \left(m_{ij} - m_j^*\right) + \left(u_{ij} - u_j^*\right)\right]} \tag{3}$$

$$d_{i^-} = \sum_{j=1}^{n} d\left(v_{ij}, v_j^-\right) = \sum_{j=1}^{n} \sqrt{\frac{1}{3}\left[\left(l_{ij} - l_j^-\right) + \left(m_{ij} - m_j^-\right) + \left(u_{ij} - u_j^-\right)\right]} \tag{4}$$

Finally, to calculate the final ratio (Eq. 5) and select (suggest) the appropriate alternative.

$$C_i = \frac{d_{i-}}{d_{i-} + d_{i*}}, C_i \in [0,1] \quad (5)$$

Whatever the final ratio of an alternative is larger, this alternative is better; because, the final ratio is the relative distance of negative ideal.

THE FRAMEWORK APPLICATION

In order to apply the framework in the real case, the data of some manufacturing activities belong to a firm that manufactures parts and subassemblies for OEMs in aviation industry were used.

For performing this framework, a cross-functional team were shaped and some workshops were implemented. During these sessions, the framework were described and considered data were collected. then, paired comparison between factors were performed (based on consensus of the team members) to determine the relative importance (or weight) of measures (as shown in Table 2).

In continuance, based on consensus of team members, Level of each factor for each alternative were recorded (in the form of linguistic variables). These levels consist of Very Low (VL), Low (L), Medium Low (ML), Medium (M), Medium High (MH), High (H) and Very High (VH) (Zimmerman, 1991; Bottani and Rizzi, 2006). This fuzzy numbers were showed in Fig. 2. Finally, based on data collected and the decision-making model, the appropriate alternative (in-house or outsourcing) were made.

In this case, the assembly of final products identified as one of the core activities. About other activities, for example, one of the nominated activity is manufacturing of a part as called DPC. This part is manufactured by casting technology. The activity of DPC manufacturing is not core and hence, retaining this activity is not necessary (the activity code is 22-CAS-DP†).

Technological capability for this activity is at high level internally and also, its potential suppliers have very capable in this way. From capacity viewpoint, the firm is average but the external suppliers have sufficient capacity. Also, internal total cost is less than the considered potential suppliers. 22-CAS-DP† doesn't contain any core competency and then, its outsourcing hasn't drawback consequences for present core competencies; although, because abondoning it may be lost a little information of firm.

After execution of the decision-making model for this activity, acquired recommend is outsourcing. The steps of the model and related computations are shown in Table 3.

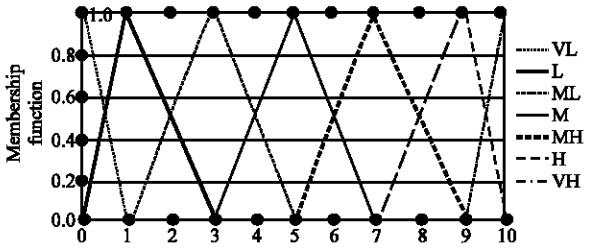

Fig. 2: Expressing the criteria levels by fuzzy numbers

Table 2: The relative importance of factors

Factors	Technological capability	Capacity	Total cost	Risk of core competency damage	Risk of important information lose	Weight
Technological capability	1.000	2.000	2.000	1.000	1.000	0.25346
Capacity	0.500	1.000	2.000	0.500	0.333	0.15071
Total cost	0.500	0.500	1.000	0.500	0.333	0.10657
Risk of core competency damage	1.000	2.000	2.000	1.000	3.000	0.25346
Risk of important information lose	1.000	3.000	3.000	0.333	1.000	0.23581

Table 3: An example of calculations for 22-CAS-DP†

Activity	Technological capability (0.17614)	Capacity (0.11254)	Total cost (0.07189)	Damage of core competency risk (0.45016)	Lose of important information risk (0.18927)
Activity code: 22-CAS-DP†					
In-house	H	M	ML	VL	VL
Outsourcing	VH	H	M	VL	L
In-house	(7,9,10)	(3,5,7)	(1,3,5)	(0,1,1)	(0,1,1)
Outsourcing	(9,10,10)	(7,9,10)	(3,5,7)	(0,1,1)	(0,1,3)
In-house	(0.7, 0.9, 1)	(0.3, 0.5, 0.7)	(1, 0.33, 0.2)	(1, 0.01, 0.01)	(1, 0.01, 0.01)
Outsourcing	(0.9, 1, 1)	(0.7, 0.9, 1)	(0.33, 0.2, 0.14)	(1, 0.01, 0.01)	(1, 0.01, 0.003)
In-house	(0.133,0.158,0.176)	(0.033,0.056,0.079)	(0.072,0.024,0.014)	(0.45,0.004,0.004)	(0.197,0.002,0.002)
Outsourcing	(0.158,0.176,0.176)	(0.079,0.101,0.112)	(0.024,0.014,0.01)	(0.45,0.004,0.004)	(0.197,0.002,0.0006)

	D*	D-	C	Suggested alternative	Value
In-house	0.64704	0.62685	0.49208	Outsourcing	0.52098
Outsourcing	0.60231	0.65508	0.52098		

Table 4: Outsourcing decision-making for five manufacturing activities

	Technological capability		Total cost		
Activity	Suitable alternative	Capacity	Outsourcing	Damage of core competency risk	Lose of information risk
Activity code: 22-CAS-DP					
In-house	H	M	ML	VL	VL
Outsourcing	VH	H	M	VL	L
Activity code: 22-ASM-BLBD					
In-house	H	ML	M	VL	VL
Outsourcing	MH	MH	M	H	VH
Activity code: 22-ASM-MIN-BD					
In-house	H	ML	M	VL	VL
Outsourcing	H	H	M	MH	VH
Activity code: 22-ASM-SUBS					
In-house	VH	L	M	VL	VL
Outsourcing	VH	H	M	L	M
Activity code: 22-MAN-MEC					
In-house	VH	H	MH	VL	VL
Outsourcing	VH	H	M	VL	ML

Moreover, the results of decision-making for five activities (this activity beside to other four activities) have been shown in Table 4.

CONCLUSIONS

The identified gaps from the literature review consisted of little attention to mathematical modeling in decision-making outsourcing problems and considering this problem as a multi-criteria problem and also, lacking appropriate access to reliable data in real environments. By developing the proposed framework, has been tried to remove these shortcomings; meanwhile, the framework in this article has been developed for manufacturing activities.

Applicability is one of the strengths of this framework. Beside to, the concentration on the core activities and retaining them inside the firm in order to protect competitive advantages is another sufficiency dimension of this framework. Although, identification of the core activities and how to enrichment of the firm`s ability is required to deeper studies.

Another strength of this framework is a decision-making model based on multi-criteria technique (TOPSIS) and linguistic judgements that were resulted to using fuzzy sets; hereby, data gathering has been facilitated and the results is more adequate; but, due to framework application has been understood that the model in second phase is sensitive to weights and hence, in future research paying attention to this issue is necessary.

REFERENCES

Arnold, U., 2000. New dimensions of outsourcing: a combination of transaction cost economics and the core competencies concept. Eur. J. Purchasing Supply Manage., 6: 23-29.

Bottani, E. and A. Rizzi, 2006. A fuzzy TOPSIS methodology to support outsourcing of logistics services. Supply Chain Manage. An Int. J., 11: 294-308.

Canez, L, K.W. Platt and D.R. Probert, 2000. Developing a framework for make-or-buy decisions. Int. J. Operations Prod. Manage., 20: 1313-1330.

Chupra, S. and P. Meindl, 2007. Supply Chain Management: Strategy. Planning and Operations, Pearson Education, New Jersey.

Cox, A., 1997. Business Success. Earlsgate Press, Boston.

Fill, C. and E. Visser, 2000. The outsourcing dilemma: A composite approach to the make or buy decision. Manage. Decision, 38: 43-50.

Fine, C.H. and D.E. Whitney, 1996. Is the Make or Buy Decision and Core Competence?. MIT Center for Technology, Policy and Industrial Development, Cambridge, MA.

Henny van de, W. and H.P. van Peet, 2006. A decision support model based on the analytic hierarchy process for the make or buy decision in manufacturing. J. Purchasing Supply Manage., 12: 258-271.

Hwang, H.S., W.H. Ko and M.J. Goan, 2007. Web-based multi-attribute analysis model for make-or-buy decisions. Mathematical Comput. Modeling, 46: 1081-1090.

Insinga, R.C. and W.J. Michael, 2000. Linking outsourcing to business strategy. Acad. Manage. Executive, 14: 58-70.

Jennings, D., 1997. Strategic guidelines for outsourcing decisions. Strategic Change, 6: 85-96.

Kremic, T., O.I. Tukel and W.O. Rom, 2006. Outsourcing decision support: A survey of benefits, risks and decision factors. Supply Chain Manage. An Int. J., 11: 467-482.

Leong, G.K., D.L. Snyder and P.T. Ward, 1990. Research in the process and content of manufacturing strategy. OMEGA Int. J., 18: 109-122.

Mantel, S.P., M.V. Tatikonda and Y. Liao, 2006. A behavioral study of supply manager decision-making: Factors influencing make versus buy evaluation. J. Operations Manag., 24: 822-838.

Mclvor, R.T. and P.K. Humphreys, 2000. A case-based reasoning approach to the make or buy decision. Integrated Manufacturing Syst. J., 11: 295-310.

Mclvor, R.T., P.K. Humphreys and W.E. McAleer, 1997. A strategic model for the formulation of an effective make or buy decision. Manage. Decision, 35: 169-178.

Pandey, V. and V. Bansal, 2004. A decision-making framework for IT outsourcing using the analytic hierarchy process. Proceedings of the International Conference on Systemics, Cybernetics and Informatics, Oct. 14, Indian Institute of Technology Kanpur, Kanpur, India, Hyderabad, pp: 1-7.

Perrons, R.K., 2004. Make-Buy decisions in the face of radical innovations. Ph.D. Thesis, University of Cambridge, Cambridge, United Kingdom.

Platt, K.W., D.R. Probert and L. Canez, 2002. Make vs. buy decisions: A process incorporating multi-attribute decision-making. Int. J. Prod. Econ., 77: 247-257.

Probert, D.R., 1997. Developing a Make-or-Buy for Manufacturing Business. Institute of Electrical Engineers, UK.

Probert, D.R., L. Canez and K.W. Platts, 2001. Technology transfer and succession planning: The relevance of make-or-buy analysis. Proc. Portland Int. Conf. Manage. Eng. Technol. Portland Oregon, 2: 439-443.

Quinn, J.B. and F.G. Hilmer, 1994. Strategic outsourcing. Sloan Manage. Rev., 35: 43-55.

Tayles, M. and D. Colin, 2001. Moving from make/buy to strategic sourcing: The outsource decision process. Long Range Plann., 34: 605-622.

Venkatesan, R., 1992. Strategic sourcing: To make or not to make. Harvard Business Review, November-December, pp: 98-107. http://hbr.org/product/strategic-sourcing-to-make-or-not-to-make/an/92610-PDF-ENG.

Wang, J.J. and D.L. Yang, 2007. Using a hybrid multi-criteria decision aid method for information systems outsourcing. Comput. Operations Res., 34: 3691-3700.

Welch, J.A. and P.R. Nayak, 1992. Strategic sourcing: A progressive approach to the make-or-buy decision. Acad. Manage. Executive, 6: 23-31.

Zimmermann, H.J., 1991. Fuzzy Set Theory and its Applications. 2nd Edn., Kluwer Academic Publishers, Boston, MA.