Development of a Decision Model for Supplier Selection

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The purpose of this study is to develop a model to help decision makers with their sourcing decisions. The outsourcing decisions that are strategically sound still need to address another important issue, the supplier selection. The attempt here is to develop a model that provides guidelines for the decision makers for selecting the appropriate supplier once their sourcing option is determined to be a sound decision. The intangible benefits and costs (risks) of outsourcing are identified, and the importance of these risks and benefits for the decision maker is solicited. In addition, the decision maker's perceptions on the likelihood of delivery of these risks/benefits by potential suppliers are included in the analysis. Thus, tangible and quantitative as well as less tangible and qualitative factors are considered as supplier selection criteria in this decision model. In particular, the decision maker's judgment on supplier's performance on delivery of the costs/benefits of outsourcing plays an important role in the selection process.

INTRODUCTION

The published literature on outsourcing can be divided into two general categories: the first category deals with the *outsourcing decision* by identifying risks and benefits of outsourcing, and the second category is the related area of *supplier selection.* Focus of this study is on the second category, supplier selection. A brief overview of the works done in this area follows:
Supplier Selection is the focus of many published literature since choosing the right supplier is the key to success of every outsourcing decision. Several analytical approaches have been introduced in the literature for evaluating suppliers. These techniques along with the corresponding authors are listed below:

Title of the model or technique	Authors
categorical method	Timmerman, 1986
vendor performance matrix approach	Soukup, 1987
Vendor profile analysis (VPA)	Thompson, 1990
Analytical Hierarch Process (AHP)	Nydick & Hill, 1992
Fuzzy Analytical Hierarchy Process	Kahraman et al, 2003
Multi-Objective Programming (MOP)	Weber & Ellram, 1993
Multi-Attribute Utility Theory (MAUT)	Min, 1994

Cost-ratio models	Dobler et al, 1990,
	Kemp, 2002
AHP and Muti-Attribute Utility Theory combined	Teng & Jaramillo, 2005
Price, cost, and value analysis approach	Batdorf & Vora, 1983
Customer Relationship Management (CRM) and Supplier Relationship Management (SRM)	Choy et al, 2004
Multi-attribute Analysis	Mclover & Humphreys, 2000
Multivariate Analysis	Lasch & Janker, 2005
Generic Supplier Management Tool (GSMT) using Case Based Reasoning (CBR)	Choy & Lee, 2003
various mathematical techniques	Cebi & Bayraktar, 2003
	Barla, 2003
	Dogan & Sahin, 2003
Total Cost of Ownership and AHP	Bhutta & Huq, 2002
Dynamic strategic decision model using Analytical Network Process (ANP)	Sarkis & Talluri, 2002
Interpretive Structural Modeling (ISM)	Mandal & Deshmukh, 1994
Dimensional Analysis	Willis et al., 1993
Human Judgment Models	Patton, 1996
VSS for cooperative customer/supplier relationships	Masella & Rangone, 2000
Principal component analysis	Petroni & Braglia, 2000
Linear Programming and AHP	Ghodsypour & O'Brien, 1998

Most of the work has been focused on identifying the relevant attributes utilized in supplier selection decisions. However, little study is done to bring in the risks and/or benefits of outsourcing in the evaluation of the potential suppliers. Even fewer attempts have been made to reflect the decision maker's perception on the importance of these factors and the likelihood of delivery of these risks/benefits by suppliers. The attempt here is to enhance the evaluation process by including the benefits/risks of outsourcing as well as the decision maker's judgment on the importance of these factors in the decision model.

The purpose of this study is to provide a tool for the decision makers to help them with their outsourcing decisions. Two questions need to be answered for any outsourcing decision: *should the firm outsource*? if the answer is yes, *which supplier should the firm select for outsourcing?* The conditions under which the outsourcing is a sound option have been identified by several studies in the literature. The general consensus is that if the activity under consideration is not a core competency and the firm's technological position is not that strong, then that activity is a good candidate for outsourcing. The focus of this study however, is on the second question, selecting appropriate supplier once it is determined that outsourcing is strategically a sound decision for the firm.

The decision model developed here includes both intangible costs (risks) and benefits of the outsourcing option in the evaluation process. The potential suppliers are then evaluated based on obvious and tangible factors as well as the less tangible factors. The importance of these intangible benefit/risk factors varies by decision makers. Also the likelihood of them being

materialized depends on decision maker's perception of the performance of the supplier. To reflect this, the decision maker's preference and perception are elicited through a set of utility questions. A supplier is then selected based on their performance with respect to these risk and benefit categories. By evaluating suppliers based on strategic factors both tangible and intangible, the decision maker can make a more informed decision that is in line with the firm's long-term objectives.

Section II provides an overview of the model. Detailed explanation of different segments of the model is covered in section III. An illustrative example is provided in section IV, and finally the paper closes with concluding remarks and suggestions for future research in section V.

II. THE SUPPLIER SELECTION MODEL

The value chain in manufacturing companies includes the following activities: research & development, product design, process design, production, marketing, and distribution. Each of these activities has a contribution to the firm's profits and could be a potential candidate for outsourcing. The model proposed here starts with the premise that it is already determined that outsourcing any of the aforementioned activities is strategically a sound decision. Thus, the focus here is on the supplier management side of the sourcing decision. The elements of supplier management are (Lasch & Janker, 2005): supplier identification, supplier limitation, supplier analysis, supplier rating, supplier selection, and supplier control. The focus of this study is mainly on the supplier rating element which leads to the supplier selection.

Furthermore, it is assumed that supplier selection can be done with no constraint. In other words, all potential suppliers can satisfy the company's requirements of demand, quality, delivery, etc. Thus, "single sourcing" is possible and the decision maker has to make only one decision; which supplier is the best. No decision needs to be made on the amount of purchase from each supplier. The detailed explanation of the steps of the model provided in the following section and their sequence is shown in the process flow diagram depicted in figure 1.

III. SUPPLIER SELECTION PROCESS

The purpose here is to identify the best supplier based on both quantitative and qualitative attributes. Suppliers are compared with respect to the benefits they offer and importance of these benefits to the decision maker. In addition, the level of risks associated with an outsourcing decision is measured for each supplier. The supplier that offers the most benefits with minimum risks is the optimal choice. Supplier selection process has two phases: economic justification phase and selection phase which are explained below:

Economic Justification Phase
Even though the sourcing decision is determined to be strategically sound, the economic feasibility of such decision should be considered as well. Economic justification starts with calculation of all costs associated with the sourcing decision. The total cost of outsourcing for each potential supplier/vendor is calculated. These total costs are then compared with the total costs of producing the product or providing the service in-house.

FIGURE 1
PROCESS FLOW CHART FOR SUPPLIER SELECTION MODEL
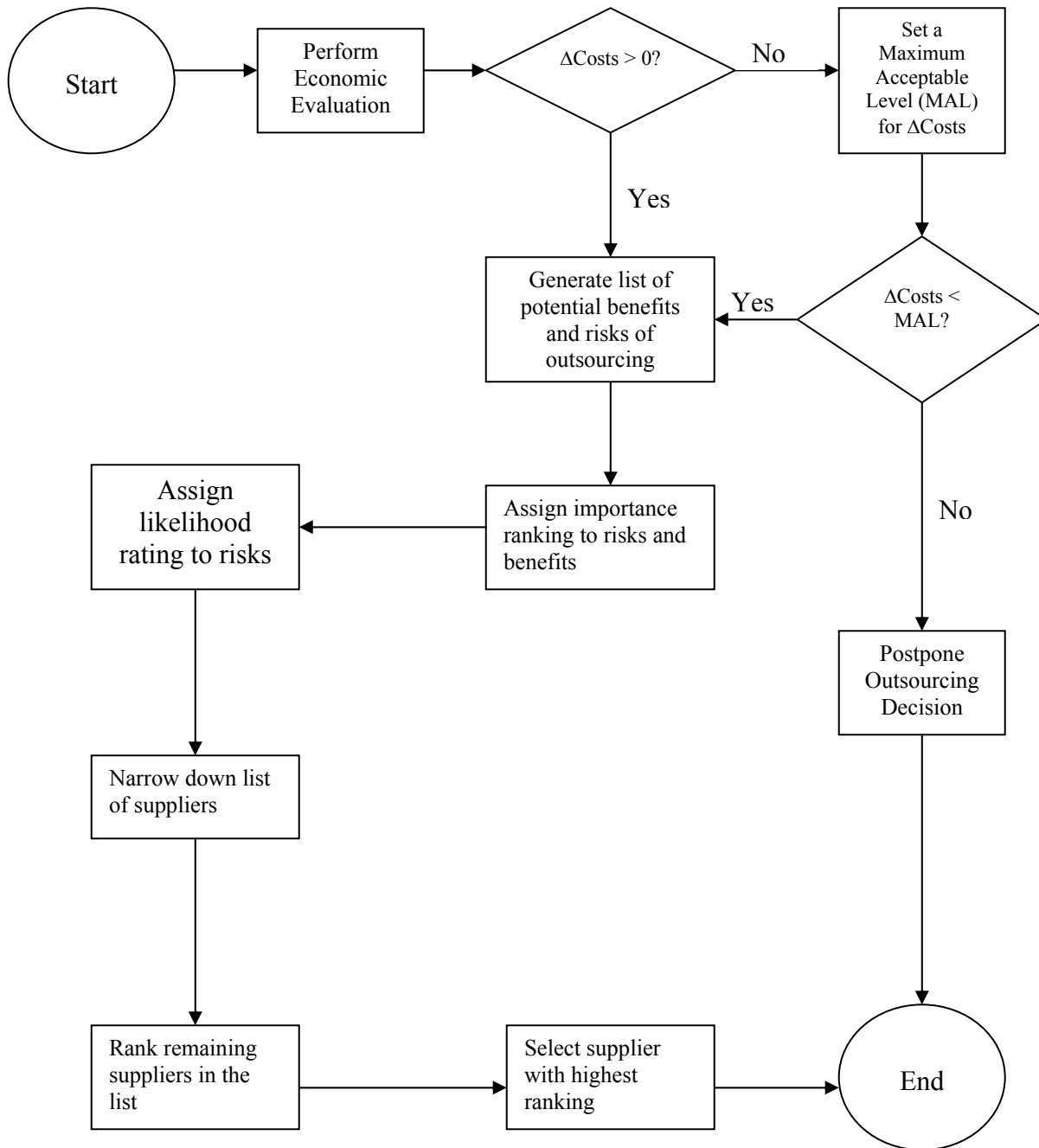
To calculate total outsourcing costs and in-house production costs, the individual cost elements should be identified. The in-house cost elements are: labor costs, material costs, capital costs, and overhead costs. The outsourcing cost elements are: unit purchase price, transportation costs, administration costs, and other costs. Detailed definitions of these costs are provided by (Ordoobadi, 2005).

Total Cost $_{(\text{in-house})}$ $TC_{\text{in-house}}$:   Total in-house production cost is the sum of labor costs, material costs, capital costs, and overhead costs.

Total cost $_{(\text{outsourced})}$ $TC_{\text{outsource}}$:   Total outsourced cost is the sum of the purchase price, transportation costs, administrative costs, and other costs.

Now, Δcosts function can be defined as: Δcosts = $Tc_{\text{in-house}}$ - $TC_{\text{outsource}}$

>   if Δ costs > 0   outsourcing has cost advantage
>   If Δ costs < 0   in-house production has cost advantage

Thus, conclusion may be drawn that outsourcing is economically feasible if Δ costs > 0, and economically infeasible otherwise. However, the calculation of sourcing costs and in-house production costs is based solely on tangible factors that are quantifiable. Thus, the conclusions made based on the result of an economic evaluation might not be totally valid. The inclusion of intangible factors associated with an outsourcing activity could very well reverse the result of the economic analysis. Therefore, intangible benefits and costs (risks) of sourcing should be identified and included in the analysis to provide a more accurate justification mechanism.

Therefore, regardless of the result of the economic analysis, the model proceeds to the next phase of ranking and selection of a supplier. In the case of economically justified sourcing decision, the purpose is basically ranking of the suppliers and then selecting the "right" supplier. For the case that sourcing is economically infeasible, the main task is to test if the inclusion of intangibles could make the sourcing option more attractive. The ranking of the suppliers then follows. In the following section, this procedure is explained in detail.

Selection Phase

The selection process starts by using the result of the economic analysis. The evaluation of intangible costs and benefits are added to the economic justification to provide a more accurate analysis. The selection process is conducted for two cases: 1) Δcosts <0; 2) Δcosts >0; the explanation of these two scenarios follows:

1. A negative gap exists between outsourcing costs and in-house production costs ($\Delta cost$<.0). That is, outsourcing the activity is more expensive than performing it in-house. Of-course the magnitude of the gap between the sourcing costs and in-house production costs is very important in determining whether inclusion of the intangibles is even an option. The decision maker will decide how small the gap should be to warrant further considerations. Thus, a maximum acceptable level for the gap is set by the decision maker. If the gap between the sourcing costs and the in-house production costs is above the maximum acceptable level, then no further analysis is needed. The sourcing decision is not justified and should be postponed for now. In other words, the decision maker believes that the economic gap is too large to be compensated by inclusion of the intangible factors in the analysis.

A gap less than the maximum acceptable level might be compensated by considering intangibles. The importance of these intangibles varies for each decision maker. The intangibles associated with any outsourcing activity could fall into two categories: intangible benefits, and intangible costs (risks). Both of these categories should be included in the selection phase. However, they are treated differently in the evaluation process. Detailed explanation of the evaluation of the intangible benefits and risks categories follows.

Evaluation of Intangible Benefits

A list of possible benefits that could materialize from a sourcing decision is provided for the decision maker's evaluation. This list is compiled from the available literature on the subject. Some benefits offered by outsourcing cited in the literature are (Chalos 1995, McCarthy 1996):

- Higher level of flexibility with less restriction from the rules existing in the company.
- Increased responsiveness to customers' needs.
- Providing special services to the customers through outsourcing without the need to hire special skill workers.
- Liability and risk reduction. Outsourcing can reduce many sources of risk and potential liability faced by manufacturers like: safety, EEO, ADA, workers' compensation, etc.
- Reduction of capital investment and labor requirements.
- Lower capital risk.
- Access to the innovations and developments of more specialized suppliers.
- Cost reduction because of the supplier's economies of scale.
- Greater focus of resources on core and high value-added activities.

Not all benefits are pertinent to the organizational goals and some are more important than others. The decision maker first selects the benefits that are relevant to his/her situation. The decision maker is then asked to rank these benefits from very important to somewhat important. Thus, the list of benefits is narrowed down by eliminating the ones that are not pertinent to the organization's outsourcing activity. A sample format of the utility calibration questions is provided in table 1.

TABLE 1
SAMPLE FORMAT FOR THE UTILITY CALIBRATION PROCEDURES

Outsourcing Benefits	Useful for Consideration?		Importance		
higher flexibility	Yes	No	VI	I	SI
increased responsiveness to customers' needs	Yes	No	VI	I	SI
providing special service to customers	Yes	No	VI	I	SI
liability and risk reduction	Yes	No	VI	I	SI
reduction of capital investment	Yes	No	VI	I	SI
reduction of labor requirements	Yes	No	VI	I	SI
lower capital risk	Yes	No	VI	I	SI
access to the innovations through specialized suppliers	Yes	No	VI	I	SI
supplier's economies of skills and scale	Yes	No	VI	I	SI
focus of internal resources on high value-added activities	Yes	No	VI	I	SI
accelerate new product development	Yes	No	VI	I	SI

i.e., Please indicate which of the following benefits of outsourcing is useful in achieving your firm's objectives. Of those benefits you choose to be relevant, please indicate in the appropriate space whether that benefit is Very Important (VI), Important (I), or Somewhat Important (SI).

The likelihood of each of the important benefits being delivered by a supplier is also very critical in the evaluation process. The determination that certain benefits of outsourcing are very important to the decision maker is not enough unless the suppliers can actually deliver these benefits. Thus, the decision maker's perception on the likelihood of receiving important benefits from each supplier is elicited. The decision maker can use historical data on suppliers' performance or personal judgment to assign likelihood ratings to potential suppliers. A sample format of the likelihood rating assignment is provided in table 2. Suppliers then will be assigned a score based on the likelihood rating and importance ranking that they have received from the decision maker.

TABLE 2
SAMPLE FORMAT FOR THE LIKELIHOOD RATING ASSIGNMENT

Benefit Category	Importance Rating	Likelihood Rating		
higher level of flexibility	VI	HL	L	UL
accelerated new product development	VI	HL	L	UL
lower capital risk	VI	HL	L	UL
Liability reduction	I	HL	L	UL
cost reduction	I	HL	L	UL
reduction of labor requirements	I	HL	L	UL
greater focus of resources on high-value added activities	I	HL	L	UL
responsiveness to customers' needs	SI	HL	L	UL
providing special services to the customers	SI	HL	L	UL

i.e., Importance ratings are provided based on your responses to the utility calibration questions. Please assign a likelihood rating to each of the following benefit categories. In the appropriate space indicate the likelihood rating as Highly Likely (HL), Likely (L), and Unlikely (UL). Assigning a Highly Likely rating for a benefit category to a supplier means that you believe that the delivery of the benefit by this supplier is highly likely.

Evaluation of Intangible Costs

Any sourcing decision has certain risks (costs) that might not be quantifiable to be included in the calculation of outsourcing costs. Thus, these risk factors should also be identified and included in the evaluation process as was done for the intangible benefits. Therefore, a list of intangible costs (risks) that could materialize from a sourcing decision is provided for the decision maker's consideration. This list is compiled from the available literature on the subject. Some of the risks associated with outsourcing cited in the literature are (Friedman 1991, Raistrick 1993):

- Lack of control on the quality of the product/service provided by the suppliers.
- Inability to meet fluctuations in demand for the product/service that has been outsourced.
- Loss of control over suppliers. Possibility of suppliers becoming a competitor for the firm themselves or assisting the firm's competitors.
- Negative impact on employees' morale.
- Loss of critical skills or developing the wrong skills.
- loss of cross-functional skills.

Not all risk categories are pertinent to the outsourcing activity in question, and some are more important than others. The decision maker first selects the risk categories that are relevant to his/her situation. The decision maker is then asked to rank these risk factors from very important to somewhat important. These rankings are associated with how badly the decision maker wants to avoid the risk. A very important ranking assigned to a risk factor means that it is critical for the firm to avoid this risk factor. A very low importance ranking assigned to a risk factor means that the company probably can live with that risk factor. A sample format of utility calibration questions is provided in table 3.

TABLE 3
SAMPLE FORMAT FOR THE UTILITY CALIBRATION PROCEDURE

Risk Factor	Applicable?		Importance		
lack of control on the quality of product/service	Yes	No	VI	I	SI
inability to meet fluctuations in demand	Yes	No	VI	I	SI
possibility of the suppliers becoming a competitor for the firm	Yes	No	VI	I	SI
negative effect on employees' morale	Yes	No	VI	I	SI
loss of critical skills	Yes	No	VI	I	SI
loss of cross-functional skills	Yes	No	VI	I	SI

i.e., Following is a list of possible risk factors associated with an outsourcing activity. Please indicate which of these factors are pertinent to your firm. Of those factors you choose to consider, please indicate in the appropriate space whether the risk factor is Very Important (VI), Important (I), or Somewhat Important (SI). The ratings of the risk factors are based on the degree of avoidance. That is, a VI rating is assigned to a risk factor if the firm absolutely has to avoid that risk.

The likelihood of the relevant risk categories being delivered by a supplier is also very important and should be considered in the evaluation process. Thus, the likelihood ratings associated with these factors are elicited from the decision maker based on his/her perception. Historical data, and/or decision maker's personal judgment can be used for assigning these likelihood ratings to different suppliers. A sample format of the likelihood rating assignment is provided in table 4. The potential suppliers are then assigned a score based on their importance ranking and likelihood ratings.

TABLE 4
SAMPLE FORMAT FOR THE LIKELIHOOD RATING ASSIGNMENT

Risk Category	Importance Rating	Likelihood Rating		
loss of cross-functional skills	VI	HL	L	UL
possibility of suppliers becoming a competitor for the firm	VI	HL	L	UL
loss of critical skills	I	HL	L	UL
inability to meet fluctuations in demand	SI	HL	L	UL
negative impact on employees' morale	SI	HL	L	UL

i.e., Importance ratings are provided based on your responses to the utility calibration questions. Please assign a likelihood rating to each of the following risk categories. In the appropriate space indicate the likelihood rating as Highly Likely (HL), Likely (L), and Unlikely (UL). Assigning a Highly Likely rating for a risk category to a supplier means that you believe that the delivery of the risk by this supplier is highly likely.

The results of the two previous analyses are combined to come up with the list of suppliers that meet both requirements. Namely, high likelihood ratings associated with important benefits and low likelihood ratings associated with important risk factors. This new list will be used for the selection purpose. The decision maker will rank the remaining suppliers on the list. The ranking of the suppliers is done by using a scoring scheme to come up with a final score for each potential supplier.

The scoring scheme proposed here is based on assigning individual scores to each supplier for the combinations of importance ranking and likelihood rating of the costs categories as well as benefits categories. The aggregate score that a supplier receives is then calculated by adding his/her individual scores from the costs and benefit categories. The mechanism for assigning scores to the suppliers and calculations of the aggregate scores is built into the model and is done internally once the decision maker's preferences and perceptions on the importance ranking and likelihood ratings are elicited. Obviously, the scoring scheme will be different for costs and benefits. The following ranking scheme is proposed:

Benefits	supplier's score	Risks	supplier's score
(VI, HL)	6	(VI, UL)	6
(I, HL)	5	(I, UL)	5
(VI, L)	4	(I, L)	4
(I, L)	3	(VI, L)	3
(I, UL)	2	(I, HL)	2
(VI, UL)	1	(VI, HL)	1

where, VI: very important; I: important;   HL: highly likely; L: likely; and UL: unlikely

For example, a supplier that the decision maker believes is highly likely to deliver a very important benefit (VI, HL) will get the highest score, while a supplier that in decision maker's opinion has a very slim chance of delivering a very important benefit (VI, UL) will receive the lowest score. The scoring would be in reverse order while considering risks of outsourcing. If a decision maker believes that it is unlikely that a supplier will deliver a very important risk category (VI, UL) this supplier receives the highest score.

Of-course, the above proposed scheme is just one of many different scoring schemes that can be used to rank the potential suppliers. Each firm can develop its own unique ranking scheme. The decision maker can use linear weighting model or any other technique for selection purposes. Some decision makers might feel that different weights should be assigned to benefits and risk factors. Some prefer to assign equal weights to both benefit and risk factors. Based on the ranking scheme used by the decision maker, the supplier with the highest ranking is selected.

2. The outsourcing option is cheaper than the in-house production alternative (Δ cost> 0).

The outsourcing activity is financially justified and the ranking of the suppliers is the main focus here. The suppliers can be ranked according to their cost of providing the service. However, a selection based on this ranking is inaccurate, since the ranking is based solely on tangible factors. The ranking of the suppliers could very well change by inclusion of the intangible benefits/costs that could materialize from an outsourcing decision. Thus, a list of intangible factors is provided for the decision maker to include in his/her evaluation process. The importance ranking and likelihood ratings are elicited from the decision maker in the same manner as mentioned in the previous case. Suppliers will be assigned scores based on the

combination of importance rankings and likelihood ratings of the cost and benefit categories. The supplier with the highest score will then be selected.

IV. AN ILLUSTRATIVE EXAMPLE

Following hypothetical example is presented here to show the application of the proposed model. The XYZ company is a Widget manufacturing company. Recently, the company has investigated the possibility of outsourcing a certain part, and the study concluded that outsourcing is strategically a sound decision for the company. Now this company is faced with selecting the appropriate supplier from the two potential suppliers. These suppliers are hereafter referred to as supplier A and supplier B.

Calculations of the total cost of outsourcing the component and producing it in-house resulted in a negative Δ cost (Δ cost = -8000) , which means outsourcing the component will cost the company $8,000 more than producing it in-house. However, the president of the company who is the sole decision maker has set the maximum acceptable level of negative gap as $10,000; that is he/she believes that this amount of negative gap might be compensated for by adding intangibles. Using the methodology of the proposed model, the decision maker will go through the following steps:

- The list of potential benefits resulting from the outsourcing activity is reviewed.
- This list is narrowed down by identifying the relevant benefits. The pertinent benefits are then ranked from very important to somewhat important.
- The likelihood ratings are assigned to both suppliers A and B for the very important and important benefits identified from previous step. The individual and total scores for the two suppliers are determined internally by the model. The results of the previous steps are summarized in table 5.

TABLE 5
SUMMARY OF BENEFIT CATEGORY EVALUATIONS FOR SUPPLIERS A AND B

Benefit Category	Importance Rating	Likelihood Rating (supplier A)	Likelihood Rating (supplier B)	Supplier A Score	Supplier B score
Higher level of flexibility	VI	HL	L	6	4
Reduction of capital investment	VI	UL	L	1	4
Liability reduction	I	L	UL	3	2
Cost reduction	I	UL	HL	2	5
Reduction of labor requirements	VI	L	L	4	4
Responsiveness to customers' needs	I	HL	UL	5	2
				total score = 21	total score = 21

Note: The following scoring scheme has been used.
   (VI, HL): 6, (VI, L): 4, (VI, UL): 1, (I, HL): 5, (I, L): 3, (I, UL): 2

- The list of potential risks resulting from the outsourcing activity is reviewed.
- This list is narrowed down by identifying the relevant risks. The pertinent risks are then ranked from very important to somewhat important.
- The likelihood ratings are assigned to both suppliers A and B for the very important and important risks identified in the previous step. The individual and total scores for both suppliers are determined internally by the model. The results are summarized in table 6.
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TABLE 5
SUMMARY OF RISK CATEGORY EVALUATIONS FOR SUPPLIERS A AND B

Risk Category	Importance Rating	Likelihood Rating (supplier A)	Likelihood Rating (supplier B)	Supplier A Score	Supplier B score
possibility of suppliers becoming competitors	I	UL	L	5	4
loss of critical skills	VI	L	HL	3	1
inability to meet fluctuations in demand	I	HL	L	2	4
lack of control on the quality of the product/service	VI	L	UL	3	6
				total score = 13	total score = 15

Note: The following scoring scheme has been used
(VI, HL): 1, (VI, L): 3, (VI, UL): 6, (I, HL): 2, (I, L): 4, (I, UL): 5

The overall aggregate score each supplier earns is calculated internally and presented to the decision maker. The decision maker now can compare these aggregate scores and choose the desired supplier for the sourcing activity. The calculation results are summarized below:

	score (benefits)	score (risks)	aggregate score
Supplier A	21	13	34
Supplier B	21	15	36

Supplier B will be chosen for outsourcing purpose, the decision maker believes that supplier B is more likely to deliver important benefits and less likely to deliver important risks that he/she wants to avoid.

V. CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

A model was presented to help the decision makers with their outsourcing decisions. The model is intended to answer one basic question: assuming that outsourcing decision is strategically sound, *which supplier should the firm select for outsourcing?* The supplier selection criteria are based on both quantitative as well as qualitative factors. The tangible cost/benefit factors as well as less tangible and strategic factors are included in the evaluation process and ranking of the suppliers. The decision maker will identify the benefits and risks of outsourcing

that are pertinent to the firm's objectives. These benefits and risks are then ranked according to their importance. The decision maker's perception on the likelihood of these benefits/risks being delivered by suppliers also elicited. The combined analyses provide a narrowed list of suppliers that will be used for final selection. This proposed model helps the decision makers make a more informed decision regarding their sourcing decisions.

Several opportunities for further research are identified. First, it is recommended that the proposed model be implemented into a software or internet-based tool. This will allow many of the calculations such as economic evaluation and assignments of scores to the potential suppliers to be done internally with minimum input from the user. It also allows the tool to be easily accessible to the decision makers.

In addition, the list of benefits and costs categories presented to the decision maker can be enriched by seeking input from experts in this area. The list used in this study is based on the currently available outsourcing literature. It is recommended to enhance this list by preparing and sending out appropriate surveys to the experts in the field. Those involved in the outsourcing decisions definitely can add their real world experiences to the academic findings. This would provide additional support for the validity of inclusion of the benefit and risk categories in the analysis.

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