Using the Analytic Hierarchy Process to Structure the Supplier Selection Procedure

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The supplier selection problem is perhaps the most important component of the purchasing function. Some of the common and influential criteria in the selection of a supplier include quality, price, delivery, and service. These evaluation criteria often conflict, however, and it is frequently impossible to find a supplier that excels in all areas. In addition, some of the criteria are quantitative and some are qualitative. Thus, a methodology is needed that can capture both subjective and objective evaluation measures.

The Analytic Hierarchy Process (AHP) is a decision-making method for ranking alternative courses of action when multiple criteria must be considered. This article shows how AHP can be used to structure the supplier selection process. This method of selection is described, and a detailed, hypothetical example of how AHP can be used also is provided. Finally, a framework is presented that any buying organization can adapt to fit its specific set of needs.

INTRODUCTION

Supplier selection may be the single most important phase of the purchasing process.[1] The objective of this stage is to find the *optimal* supplier—not necessarily the supplier offering the best technical service or the lowest price or the shortest delivery. Thus, firms must consider multiple criteria in their attempts to distinguish between items offered by potential suppliers.[2] This article presents a framework that can be used to formalize the process of evaluating the tradeoffs between the conflicting selection criteria established by purchasers.

Current Developments in Supplier Selection

The past few years have seen the relationship between the buyer and the supplier change.[3] Historically, an adversarial or

quasi-adversarial relationship between the buyer and the seller often existed. However, current business trends, including shortened product life cycles, increased rates of technological change, and foreign sourcing,[4] have given rise to a growing trend toward improved communication and cooperation between the two parties, as well as the possibility of single sourcing rather than multiple sourcing. The implications of these recent developments are that the supplier selection decision is becoming even more important. If buyers are less willing to change suppliers, the choice of an unacceptable supplier is more damaging than it was previously. In addition, once an acceptable supplier is identified, the buyer has an opportunity to establish a long-term relationship with the supplier, which may provide a strategic advantage.[5]

The Supplier Selection Procedure

When a supplier selection decision needs to be made, the buyer generally establishes a set of evaluation criteria that can be used to compare potential sources.[6] The basic criteria typically utilized for this purpose are pricing structure, delivery (timeliness and costs), product quality, and service (i.e., personnel, facilities, research and development, capability, etc.).[7] For global markets, the set of criteria is expanded to take into account the new variables and risks associated with international business transactions.[8]

Frequently, these evaluation criteria conflict with one another. For example, one supplier may offer inexpensive parts that have slightly below average quality, while another supplier may offer higher quality parts, with uncertain delivery. In addition, the importance of each criterion varies from one purchase to the next. This situation can be complicated further by the fact that some of the criteria are quantitative (price and perhaps quality) and some are qualitative (service). Thus, a technique is needed that can adjust for the decision maker's attitude toward the importance of each criterion for each item, as well as capture both subjective and objective criteria.

Two approaches commonly used to assess supplier performance—and subsequently to assist in the sourcing decision—are the categorical and the weighted point evaluation plans.[9] The primary advantage of the categorical approach is that it helps structure the evaluation process in a clear and systematic way. Additionally, by requiring buyers to explicitly consider the evaluation criteria used in their decisions, this method compels them to determine which supplier attributes they truly value. However, an obvious disadvantage with this technique is that typically it does not clearly define the *relative* importance of each criterion. Perhaps a more important disadvantage is the fact that decisions made using this system tend to be fairly subjective.

The weighted point approach overcomes the major disadvantages of the categorical plan. As its name implies, all measurement factors are weighted for importance in each purchasing situation. And typically the system is designed to utilize quantitative measurements. The major limitation of this approach, however, is that it is difficult to effectively take qualitative evaluation criteria into consideration.[10]

One of the most recent approaches is the Vendor Profile Analysis (VPA) model. This process extends the weighted point methodology. This enhancement is accomplished by simulating the performance rating for each criterion. The VPA approach captures the uncertainty that may exist in reality, and is a substantial improvement over the single point estimate used in the weighted point method. However, it still does not adequately measure qualitative evaluation criteria.

Another methodology that can be used in the supplier selection activity is the Analytic Hierarchy Process (AHP). Narasimhan first suggested using AHP for this decision in order to overcome many of the shortcomings of the previous procedures.[11] The purpose of this article is to explore the use of this concept—and suggest an easy-to-apply methodology for many organizations in dealing with supplier selection decisions.

THE ANALYTIC HIERARCHY PROCESS

The Analytic Hierarchy Process (AHP) is a decision-making method for prioritizing alternatives when multiple criteria must be considered. It has been applied to a wide variety of decision areas, including research and development project selection,[12] evaluating alternative product formulations,[13] and selecting a microcomputer.[14] This method allows the decision maker to structure complex problems in the form of a hierarchy, or a set of integrated levels. Generally, the hierarchy has at least three levels: the goal, the criteria, and the alternatives. For the supplier selection problem, the *goal* is to select the best overall supplier. Examples of the *criteria* that might be used are quality, price, service, and delivery. The *alternatives* are the different proposals supplied by the suppliers.

The AHP offers a methodology to rank alternative courses of action based on the decision maker's judgments concerning the importance of the criteria and the extent to which they are met by each alternative. For this reason, AHP is ideally suited for the supplier selection problem.[15]

The problem hierarchy lends itself to an analysis based on the impact of a given level on the next higher level. The process begins by determining the relative importance of the criteria in meeting the goals. Next, the focus shifts to measuring the extent to which the alternatives achieve each of the criteria. Finally, the results of the two analyses are synthesized to compute the relative importance of the alternatives in meeting the goal.

Managerial judgments are used to drive the AHP approach.[16] These judgments are expressed in terms of pairwise comparisons of items on a given level of the hierarchy with respect to their impact on the next higher level. Pairwise comparisons express the relative importance of one item versus another in meeting a goal or a criterion. Each of the pairwise comparisons represents an estimate of the ratio of the weights of the two criteria being compared. This ratio scale for processing human judgments has been applied to a variety of decision-making problems in other fields, and it has been validated in situations where standard measures

(e.g., size, shape) already exist. Because AHP utilizes a ratio scale for human judgments, the alternative weights reflect the relative importance of the criteria in achieving the goal of the hierarchy.

Although there are many scales that could be used for quantifying managerial judgments, the scale given in Table I is the standard used for AHP analysis. For example, if a buyer believes that quality is moderately more important than delivery, then this judgment is represented by a 3. Judgments are required for all the criterion comparisons, and for all the alternative comparisons for each criterion. This information is usually provided by the buyer.

Table I

MEASUREMENT SCALE

Verbal Judgment or Preference	Numerical Rating
Extremely Preferred	9
Very Strongly Preferred	7
Strongly Preferred	5
Moderately Preferred	3
Equally Preferred	1

The intermediate values of 2, 4, 6, and 8 provide additional levels of discrimination.

Reciprocals: If activity *i* has a specific numerical rating with respect to activity *j*, then *j* has the reciprocal value when compared to *i*.

The pairwise comparison information for each component of the problem is represented by a *pairwise comparison matrix*. If there are n items that need to be compared for a given matrix, then a total of $n(n-1)/2$ judgments are needed. For example, if $n = 4$, only 6 judgments are needed, whereas there are $n^2 = 16$ cells in the complete matrix. There are two reasons for this apparent savings in the required number of judgments. First, since any alternative is equally preferred to itself, 1's are placed along the diagonal of the matrix. Second, the corresponding positions below the diagonals are the *reciprocals* of the judgments already entered. Assuming as before that the pairwise comparison of quality to delivery is 3, or equivalently a 3 to 1 ratio, it follows that the pairwise comparison of delivery to quality is a 1 to 3 ratio, or 1/3.

One important advantage of using AHP is that it can measure the degree to which a manager's judgments are consistent. In the real world, some inconsistency is acceptable, and even natural. For example: in a sporting contest, if team A usually beats team B, and if team B usually beats team C, this does *not* imply that team A usually beats team C. This (slight) inconsistency may result because of the way the teams match up overall. The point is to make sure that inconsistency remains within some reasonable limits. If it exceeds a specific limit, some revision of judgments may be required. AHP provides a method to compute the consistency of the pairwise comparisons. Consistency will be discussed further in the following detailed example.

An Example of Supplier Selection Using AHP

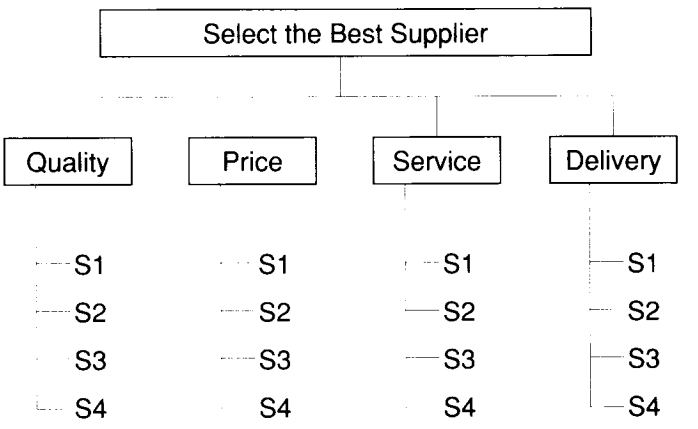
The AHP approach, as applied to the supplier selection problem, consists of the following five steps:

1. Specify the set of criteria for evaluating the supplier's proposals.
2. Obtain the pairwise comparisons of the relative importance of the criteria in achieving the goal, and compute the priorities or weights of the criteria based on this information.
3. Obtain measures that describe the extent to which each supplier achieves the criteria.
4. Using the information in step 3, obtain the pairwise comparisons of the relative importance of the suppliers with respect to the criteria, and compute the corresponding priorities.
5. Using the results of steps 2 and 4, compute the priorities of each supplier in achieving the goal of the hierarchy.

A simplified example should help illustrate the process. Assume that there are four criteria that are being used to evaluate suppliers: quality, price, service, and delivery. Further assume that proposals from four suppliers (S1, S2, S3, and S4) are being considered. The hierarchy for this application is shown in Table II.

Table II

SUPPLIER SELECTION HIERARCHY



The buyer must now develop a set of pairwise comparisons to define the relative importance of the criteria. If a buyer believes that quality is equally to moderately more important than price, a value of 2 expresses this judgment. If price is moderately more important than service, a value of 3 is appropriate. Assuming transitivity of judgments, quality would be strongly to very strongly more important than service (i.e., a value of 6).

However, as previously mentioned, judgments are not always perfectly consistent. Suppose that, for this example, quality is judged moderately to strongly more important than service, so a value of 4 is appropriate. Continuing with this process, the decision maker has decided that quality is moderately more important than delivery (i.e., a value of 3), price is moderately more important than delivery (i.e., a value of 3), and service is equally to moderately more important than delivery (i.e., a value of 2). These six judgments complete the pairwise comparisons that are needed at this stage, and are entered in a pairwise comparison matrix shown in Table III. The other entries in the matrix are 1's along the diagonal, and reciprocals of the six judgments as previously discussed.

The data in the matrix can be used to generate a good estimate of the criteria weights. The weights provide a measure of the relative importance of each criterion. This process is summarized in the following three steps:

1. Sum the elements in each column
2. Divide each value by its column sum
3. Compute row averages[17]

Table III

PAIRWISE COMPARISON MATRIX AND COMPUTATIONS: EVALUATION CRITERIA

A. Original Matrix

	Quality	Price	Service	Delivery
Quality	1	2	4	3
Price	1/2	1	3	3
Service	1/4	1/3	1	2
Delivery	1/3	1/3	1/2	1
Column Totals	25/12	11/3	17/2	9

B. Adjusted Matrix

	Quality	Price	Service	Delivery	Weights (Row Avg.)
Quality	12/25*	6/11	8/17	3/9	0.457
Price	6/25	3/11	6/17	3/9	0.300
Service	3/25	1/11	2/17	2/9	0.138
Delivery	4/25	1/11	1/17	1/9	0.105
				Total	1.000

* This entry is obtained by dividing the quality entry in the original matrix (1) by the quality column total (25/12).

The computations are shown in part B of Table III. In this example, the final weights for quality, price, service, and delivery are 0.457, 0.300, 0.138, and 0.105, respectively. Therefore, quality is judged to be about one and one-half times (0.457/0.300) as important as price, about three and one-third times (0.457/0.138) as important as service, and four and one-third times (0.457/0.105) as important as the delivery.

The AHP allows individuals to use their own personal psychometric scale for making the required pairwise comparisons. Measuring the consistency of one's judgments allows a cross-check on how well that scale is being followed. As long as the scale is applied consistently by each individual, the AHP can correctly process their judgments.

Computations of the consistency ratio are somewhat more involved, but are easily performed with a spreadsheet package such as Lotus 1-2-3, or a microcomputer software package for AHP such as *Expert Choice*.[18] For the pairwise comparison matrix given as Table III, it can be shown that the consistency is acceptable.

Next, the four suppliers must be compared pairwise for each criterion. This process is virtually identical to the procedure that was used to develop the criteria comparison matrix. The only difference is that there is a supplier comparison matrix for each criterion. Therefore, the decision maker compares each pair of suppliers with respect to the quality criterion. This is repeated for the three other criteria. Assume that the buyer provided the four pairwise comparison matrices given in Table IV. The weights of the suppliers, for each criterion, are determined using the three-step procedure previously mentioned. These weights are also shown in Table IV for each matrix.

Table IV

SUPPLIER PAIRWISE COMPARISON MATRICES AND PRIORITIES

	S1	S2	S3	S4
A. With Respect to Quality				
S1	1	5	6	1/3
S2	1/5	1	2	1/6
S3	1/6	1/2	1	1/8
S4	3	6	8	1
Weights	.297	.087	.053	.563
B. With Respect to Price				
S1	1	1/3	5	8
S2	3	1	7	9
S3	1/5	1/7	1	2
S4	1/8	1/9	1/2	1
Weights:	.303	.573	.078	.046

(continued on page 35)

SUPPLIER PAIRWISE COMPARISON MATRICES AND PRIORITIES *(continued)*

	S1	S2	S3	S4
C. With Respect to Service				
S1	1	5	4	8
S2	1/5	1	1/2	4
S3	1/4	2	1	5
S4	1/8	1/4	1/5	1
Weights:	.597	.140	.214	.050
D. With Respect to Delivery				
S1	1	3	1/5	1
S2	1/3	1	1/8	1/3
S3	5	8	1	5
S4	1	3	1/5	1
Weights:	.151	.060	.638	.151

The final step of the AHP analysis is summarized in Table V. This table shows how the overall formulation scores are computed. This procedure can be explained as a simple weighted average technique. For a given supplier, four weights are computed, one for each of the four evaluation criteria (from Table IV). These four weights are multiplied by the appropriate criteria weights in meeting the goal of the hierarchy (from Table III), and the results of the four multiplications are added together to compute the supplier score. Each supplier score represents the estimated total benefits to be obtained from selecting this supplier. In this example, supplier 1 (i.e., S1) with a score of 0.325 is judged to be best, S4 is second with a score of 0.294, followed by S2 (0.237) and S3 (0.144). Based on this simplified example, supplier 1 should be selected.

SUMMARY AND CONCLUSIONS

This article presents a formal methodology to structure the supplier selection decision process. The Analytic Hierarchy Process is used as a framework to formalize the evaluation of tradeoffs between the conflicting selection criteria associated with various suppliers' offers.

There are also a variety of extensions to the AHP approach which can increase its usefulness for managerial decision making. First, the AHP is a flexible modelling tool that can accommodate a larger set of evaluation criteria. For example, related criteria can be grouped into categories such as quality, price, delivery, and service. These categories can be compared pairwise first, and then the individual criteria can be pairwise compared within each category. In this way, a larger number of criteria can be included within the hierarchy without generating an extremely large pairwise comparison matrix.

A second extension involves the use of AHP to support a group decision-making process. This can be accomplished in several ways. In the most common approach, each individual in the group performs the AHP analysis separately (and anonymously if desired). The results are reported to the group, and discussion among the group members follows. This cycle is repeated as often as necessary until a consensus is reached.

Use of the AHP approach offers a number of benefits. One important advantage is its simplicity. The AHP can also accommodate uncertain and subjective information, and allows the application of experience, insight, and intuition in a logical manner. Perhaps the most important advantage, however, is in developing the hierarchy itself. This forces buyers to seriously consider and justify the relevance of the criteria.

The procedures described in this article, combined with the extensions, can be valuable to all firms in their supplier selection decisions. The potential benefits that flow from this simplistic approach are a clear indication that buyers

Table V

COMPUTATION OF WEIGHTS: SUPPLIER ALTERNATIVES

	Quality		Price		Service		Delivery		Weights
S1	(.457)(.297)	+	(.300)(.303)	+	(.138)(.597)	+	(.105)(.151)	=	.325
S2	(.457)(.087)	+	(.300)(.573)	+	(.138)(.140)	+	(.105)(.060)	=	.237
S3	(.457)(.053)	+	(.300)(.078)	+	(.138)(.214)	+	(.105)(.638)	=	.144
S4	(.457)(.563)	+	(.300)(.046)	+	(.138)(.050)	+	(.105)(.151)	=	.294
								Total	1.000

should consider its use when making certain types of supplier selection decisions—and that managers should use it to validate and reinforce previous decisions.

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