



## Selecting suppliers in supply chain with the help of AHP and ANP methods.

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### Abstract

*It is often seen that in industry the decisions are taken based on rule of thumb rather on some modern decision making techniques. It occur either due to lack of knowledge towards the new techniques or due to improper application of these techniques. The decision-making represents an area where mistakes can occur leading to wrong decision. This total dependence on intuitive methods often becomes a hindrance in the full utilization of the existing facilities. The challenge lies in implementing decision support system for evaluating the performance of the supply chain and displaying the solution as a demo. Motivated by this problem an attempt has been in this paper to increase the performance of a simple Supply Chain Model by adopting decision support system. In this paper the selection of suppliers are made with the help of multi criteria decision tool such as Analytical Hierarchy Process (AHP) and Analytical Network Process (ANP).*

**Keywords:** Analytical Network Process, Analytical Hierarchy Process, Multi criteria decision making, Supply chain

### 1. Introduction

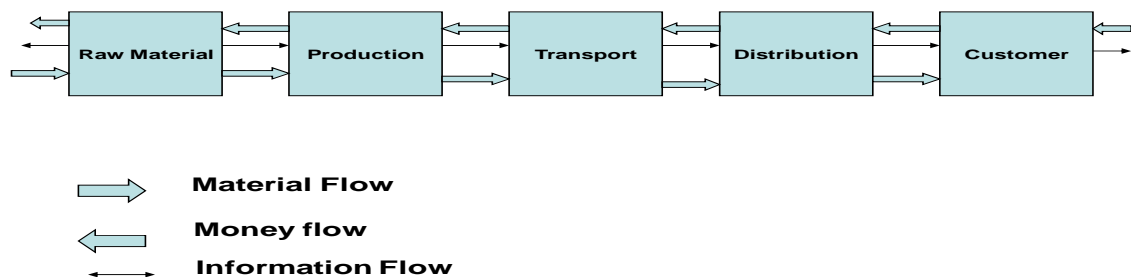
Customer satisfaction to a high degree is dependent on the flexibility of the supply chain, i.e., its ability to respond to changes in demand. General Electric, Dell Computers, Compaq and other leading firms in the USA successfully introduced this concept in the early 1990's. Levi et al. (2006) defines supply chain management as set of approaches utilized to efficiently integrate suppliers, manufacturer, warehouse, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements.

Traditionally, marketing, distribution, production, and the purchasing organizations along the supply chain operated independently. During their study Barbarasoglu and Yazgac.(1997) came out with the fact that these organizations have their own objectives and these are often conflicting. For instance, suppliers typically want manufacturers to commit themselves to purchasing large quantities in stable volumes with flexible delivery dates, Unfortunately, although most manufacturers

would like to implement long production runs, they need to be flexible to their customers' needs and changing demands. Thus, suppliers' goals are in direct conflict with the manufacturers' desire for flexibility. Similarly the manufacturer's objective of making large production batches typically conflicts with the objective of both warehouses and distribution centers to reduce inventory.

Many production operations are designed to minimize make-span and lower costs with little consideration for the impact on inventory levels and distribution capabilities. Purchasing of raw materials are often negotiated keeping in mind the cost and neglecting quality. The result of these factors is that there is not a single, integrated plan for the organization. Hence there is a need for integration of these functions. Levi et al. (2006) defines that supply chain management is a strategy through which such integration can be achieved. Therefore coordination between the various players in the chain is key in its effective management.

Chang et al. (2001) found out that the decisions for supply chain planning fall into three categories namely strategic, tactical and operational. The strategic levels deal with decisions that have a long-lasting effect on the firm. These are closely linked to the corporate strategy and include number, location, and capacity of warehouses and production plants and the flow of material through the logistics network. The tactical level includes that are typically updated anywhere between once every quarter and once every year. These include purchasing and production decisions, inventory policies, and transportation strategies, On the other hand, operational decisions are short term, and focus on activities over a day-to-day basis. This includes scheduling, lead time, routing and truck loading. The conventional supply chain is shown in fig 1.



*Figure 1 Conventional Supply Chain*

The above figure shows various stages in a supply chain. Forward arrow shows the material flow. First of all the raw material is refined that means the suitable raw material (based on shape, size, quality etc) is selected from the lot and send to the production unit .After production product is transported to the distributors. And finally the product reaches to the customer. Here the backward arrows show money flow. And two sided arrow show information flow.

## **2. Literature Review**

The literature review is done in the areas relevant to this work. This includes area such as AHP, ANP and supply chain etc.

### **2.1 Analytic Hierarchy Process (AHP)**

The AHP is designed to solve complex multi-criteria decision problems. It is based on the innate human ability to make sound judgments about small problems. It facilitates decision making by organizing perceptions, feelings, judgments, and memories into a framework that exhibits the forces that influence a decision. In AHP a problem is structured as a hierarchy. Once the hierarchy has been constructed, the decision-maker begins the prioritization procedure to determine the relative importance of the elements in each level. Prioritization involves eliciting judgments in response to questions about the dominance of one element over another with respect to a property. The scale used for comparisons in AHP enables the decision-maker to incorporate experience and knowledge intuitively and indicate how many times an element dominates another with respect to the criterion (Mohammad and Kumar, 2008). The decision-maker can express his preference between each pair of elements verbally as equally important, moderately more important, strongly more important, very strongly more important, and extremely more important. These descriptive preferences would then be translated into numerical values 1, 3, 5, 7, 9 respectively with 2, 4, 6, and 8 as intermediate values for comparisons between two successive qualitative judgments. Reciprocals of these values are used for the corresponding transposed judgments. Figure 2 shows the conceptual model of the suppliers in AHP (Boer et al. 2001)

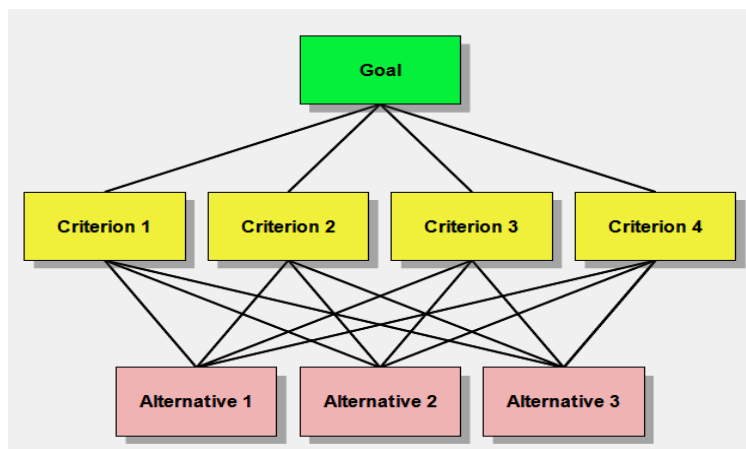


Figure 2: Conceptual Model of Supplier in AHP

The goal is shown at the top of the hierarchy. Next in the hierarchy are the criteria on the basis of which the alternatives are selected. The last level of the hierarchy is the alternatives.

## 2.2 Analytical Network Process

The ANP, developed by Thomas L. Saaty, provides a way to input judgments and measurements to derive ratio scale priorities for the distribution of influence among the factors and groups of factors in the decision. Because the process is based on deriving ratio scale measurements, it can be used to allocate resources according to their ratio-scale priorities. The well-known decision theory, the Analytic Hierarchy Process (AHP) is a special case of the ANP. Both the AHP and the ANP derive ratio scale priorities for elements and clusters of elements by making paired comparisons of

elements on a common property or criterion. Figure 3 shows the hierarchy model of ANP.

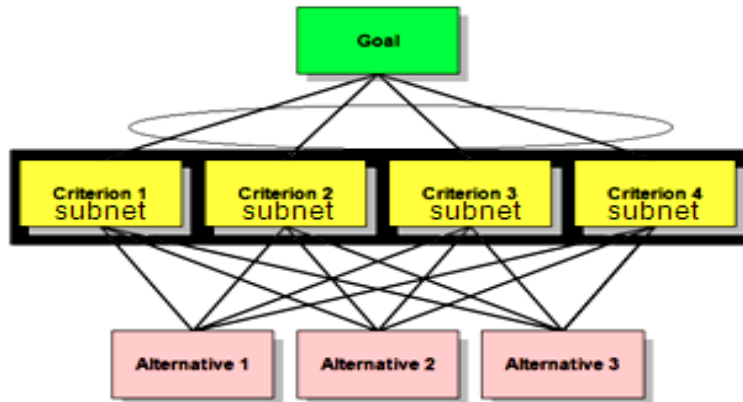


Figure 3: Conceptual Model of the supplier in ANP

The goal is shown at the top of the hierarchy. Next in the hierarchy are the criteria's on the basis of which the alternatives are selected. In ANP we can also make subcriteria of the criteria's which is not possible in AHP. The last level of the hierarchy is the alternatives. Although many decision problems are best studied through the ANP, one may wish to compare the results obtained with it to those obtained using the AHP or any other decision approach with respect to the time it took to obtain the results, the effort involved in making the judgments, and the relevance and accuracy of the results. ANP models have two parts: the first is a control hierarchy or network of objectives and criteria that control the interactions in the system under study; the second are the many sub-networks of influences among the elements and clusters of the problem, one for each control criterion (Chung et al. 2001)

### 3. Problem Formulation

Decision Support System for Supply Chain Management involves selection of supplier with the help of multi criteria decision tool such as AHP and ANP.

The problem is to assist the supply chain with a decision support system for scenarios analysis such as:

- Selecting the supplier with the help of AHP model.
- Selecting the supplier with the help of ANP model.
- Compare the results of both AHP and ANP model and find which model gives better result.
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### 4. Methodology

The supply chain under consideration involves four nodes such as supplier, production, distribution and customer (see figure 1). We consider supplier node and

evaluate different suppliers with the help of multi criteria decision making technique such as AHP and ANP.

#### **4.1 Selection of supplier with AHP method:**

##### **4.1.1 Structuring the Hierarchy**

The goal is to choose the best supplier among the three suppliers from which the manufacturer purchase the material. We placed this goal at the top of the hierarchy. The hierarchy descends from the more general criteria in the second level to the available alternatives in the third level. Figure 4.1 shows the hierarchy of structure developed in AHP.

**Goal:** Goal is shown at the top of the structure. And our goal is to select the best supplier. Next in the hierarchy is the criteria on the basis of which the alternatives are selected. The criteria under consideration are: performance, speed, service, and warranty. The last level of the hierarchy is the alternatives that are the number of suppliers. In this project we have considered three suppliers such as Asus, Intel and, Mercury. All these three suppliers supply processors to one of the reputed Computer Company of the world

In the figure 4, hierarchy model of AHP is shown. The goal is shown at the top of the hierarchy. Next in the hierarchy are the criterias that is: speed, service, performance, and warranty. On the basis of which the alternatives are selected. The last level of the hierarchy is the alternatives. The various alternatives are ASUS, INTEL, and MERCURY.

##### **4.1.2 Performing Pairwise Comparisons:**

After constructing the hierarchy, pairwise comparisons were performed systematically to include all the combinations of criteria/sub-criteria/secondary sub-criteria/ tertiary subcriteria/alternatives relationships. We compared the criteria and sub-criteria according to their relative importance with respect to the parent element in the adjacent upper level. Prior to our study, it is hoped that we would be able to go through pairwise comparisons together with the decision makers. We first made all the pairwise comparisons using semantic terms from the fundamental scale and then translated them to the corresponding numbers, separately. The questions to ask when comparing two criteria being compared, which is considered more important by the decision-maker selecting the best supplier, and how much more important is it with respect to selection of the best supplier. After performing all pairwise comparisons by the decision-makers, we aggregated individual judgments using the geometric mean as Saaty suggested (Saaty, 1990). The judgments were based upon the gathered information through the questionnaires.

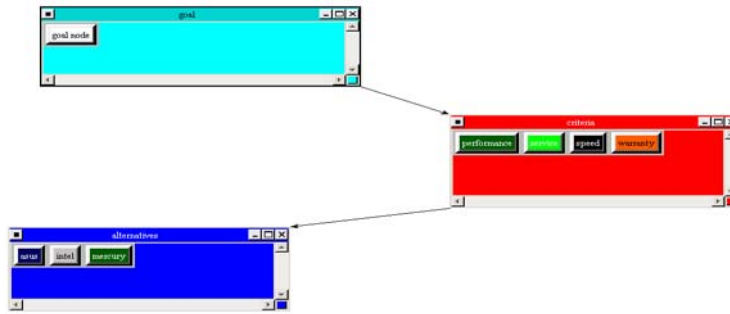


Figure 4: Structuring the Hierarchy developed in AHP

The following figure 5 and 6 shows the comparison on the basis of rating of alternatives with respect to performance and service.

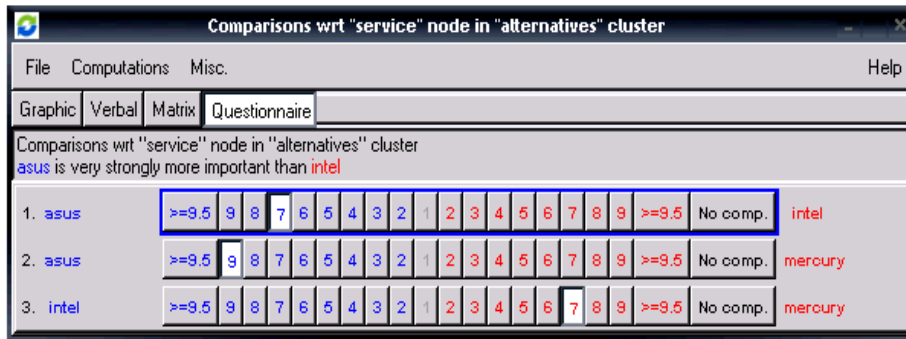


Figure 5: Comparison with respect to service in alternatives

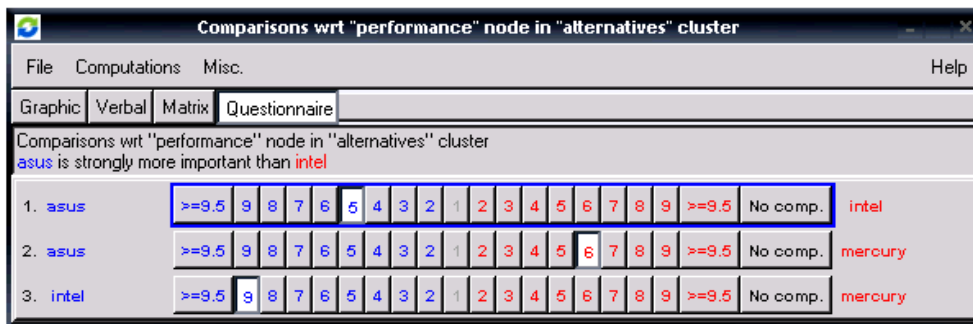


Figure 6: Comparison with respect to performance in alternatives

Figure 7 shows the alternatives with their respective priorities.

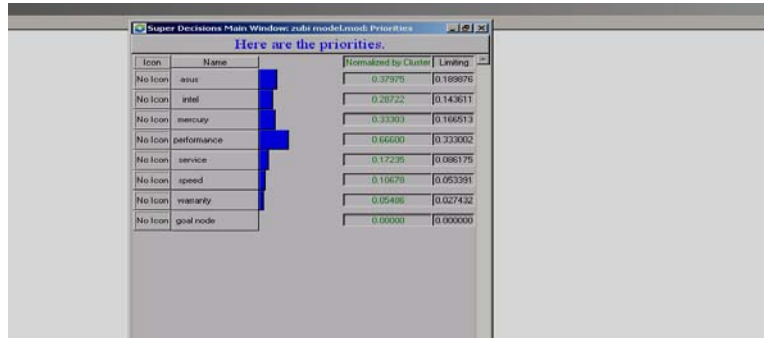


Figure 7: Alternatives with their respective priorities

Performance is the most important factor of selecting the best supplier with a priority of 0.666. Warranty is the second most important factor having priority 0.548. This is followed by service and speed having priority of 0.172 and 0.106 respectively.

#### 4.1.3 Results:

Figure 8 shows the final result of selecting the best supplier. It is seen from this figure that ASUS supplier is superior to other two supplier based on the criteria and the weightage considered for each criteria in this project. This result is for this specific supply chain. The decision may change if the criteria or its weight are changed.

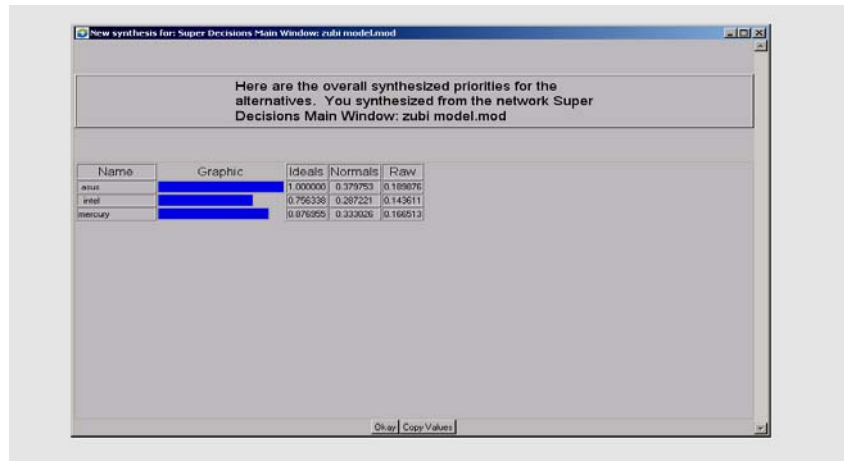


Figure 8: Alternatives with their overall priorities

Next we perform the Sensitivity Analysis to investigate the robustness of our model.

#### 4.1.4 Sensitivity Analysis:

In general terms Sensitivity Analysis investigates the robustness of a study when the study includes some form of mathematical modeling. Sensitivity analysis tries to identify what source of uncertainty weights more on study conclusion. Thus Sensitivity Analysis is the study of how the variation in the output of a mathematical model can be apportioned, qualitatively or quantitatively to different sources of

variation in the input of a model. Figure 9 shows the sensitivity analysis of our model. The figure shows when the performance criteria is 0.5 on the x-axis keeping all other three criteria constant then ASUS outperforms other two supplier such as INTEL and MERCURY. Their priorities at this level of performance are also shown in the figure by red, blue and black color respectively. Also priority can be read from y-axis.

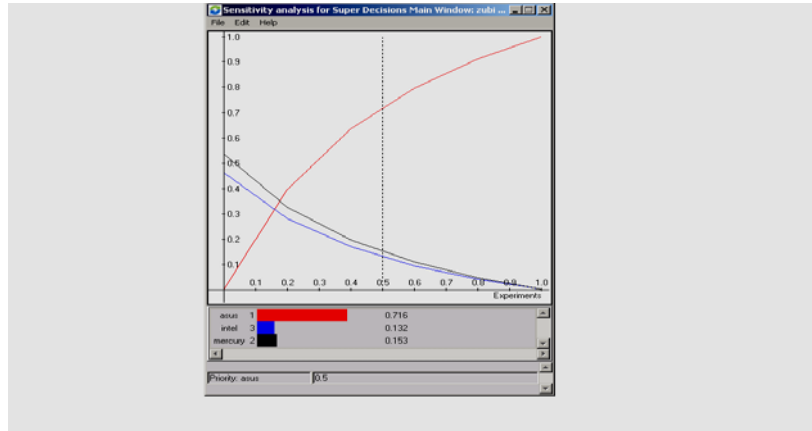


Figure 9: Sensitivity analysis of priorities on performance basis when rating of performance is fixed at 0.5

Next we change the performance criteria to 0.1 to see whether there is any change in the decision in selecting the supplier as compared to performance index of 0.5. Figure 10 shows the sensitivity analysis of the model. It is seen that in this case when the performance criteria is 0.1, then MERCURY outperforms other two suppliers. This shows that when the performance criteria are changed our decision also changes.

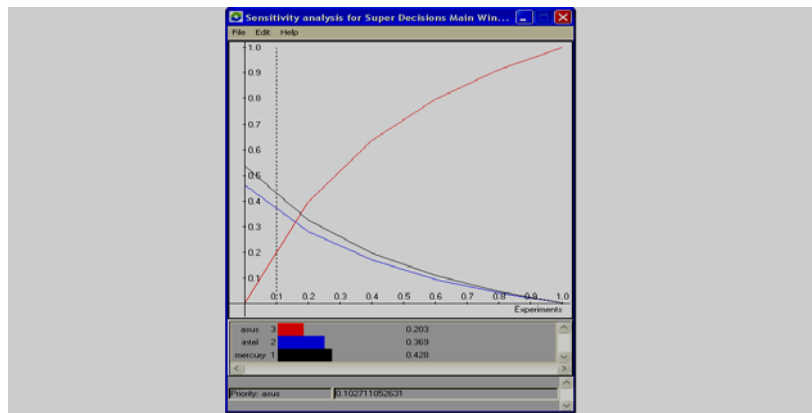


Figure 10: Sensitivity analysis of priorities on performance basis when rating of performance is fixed at 0.1

With AHP we come to the conclusion that **ASUS** is the best supplier. However, this decision is valid under the prevailing condition and assumptions. In order to get more refined result the same problem is been solved by ANP method. ANP is more general evaluation approach with- feedback that may be used to assess a dynamic multi-directional relationship among decision attributes. The ANP approach is a non-linear, network relationship among various factors such as benefit, costs and risks. In the next section we evaluate the problem with the help of ANP method.

#### 4.2 Selection of supplier with ANP method:

Many decision problems cannot be build as hierarchical because of dependencies (inner/outer), and influence between and within clusters (criteria, alternatives). Analytical Network Process (ANP) is very useful to solve this kind of problems introduced by Saaty. ANP provides a general framework to deal with decisions without making assumptions about the independence of higher-level elements from lower level elements and about the independence of the elements within a level. In this project ANP is used to develop a model for supplier selection.

- Several criterias and alternatives can be evaluated with the scope of the decision problem.
- Both objective and subjective factors can take into consideration in the decision problem.
- There exists an interaction between and within supplier selection criteria and alternatives.

The proposed ANP model for supplier selection is given in Figure 11. The step wise methodology is explained below.

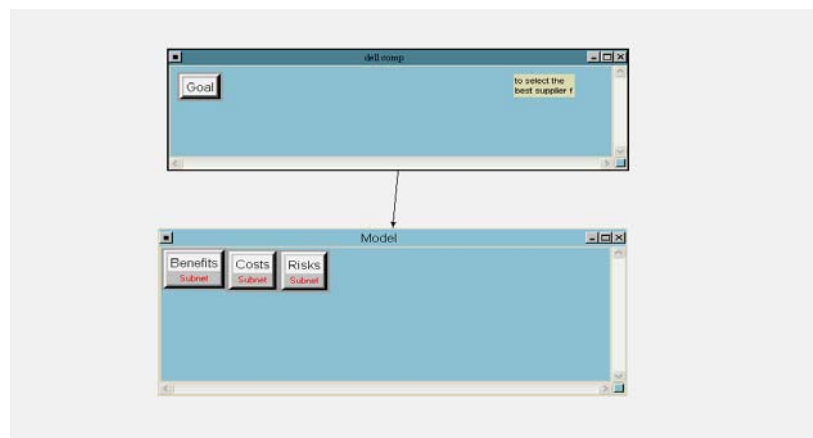


Figure 11: Highlight of Goal and Criteria (ANP)

##### Step 1:

The first step of the algorithm is the analysis of the supplier selection problem. The main goal of supplier selection problem is selecting the best supplier that meets the requirements or criteria are of the company.

##### Step 2:

For the proposed supplier selection model, overall criteria are determined under the below mentioned three criteria:

##### **BENEFIT:**

Benefit is the soul criteria of business of any organization. Benefit can be measured in terms of profit, net income etc.

**COST:**

Cost is the initial investment done while purchasing a product. It determines the worth of a product.

**RISK:**

Risk is the threat involved in purchasing a particular product.

The various sub-criteria under the criteria are:

**Benefit:**

*Trust:* Trust is the faith shown by a customer in a company while purchasing its product.

*Loyalty:* Loyalty means the promise that company will provide good service after purchase.

*Satisfaction:* Satisfaction is shown by the customer when the company fulfills all the required needs.

**Cost:**

*Initial cost:* Initial cost is the initial investment while purchasing a product.

*Repair cost:* It is the maintainance cost after purchase.

*Reliability cost:* Reliability cost stands for the brand name in market.

**Risk:**

*Financial status:* Financial status determines how strong the financial condition of the company is.

*Flexibility:* It determines how easily the supplier can meet the varying demands.

*Lead time:* It is the time taken by the supplier to supply the product.

The alternatives (suppliers) based on these criterias and subcriterias are:

1. ASUS
2. INTEL
3. MERCURY

We have chosen these alternatives as they are well recognized and reputed supplier of the market. Figure 12 and 13 shows the comparison of goal with various criteria.

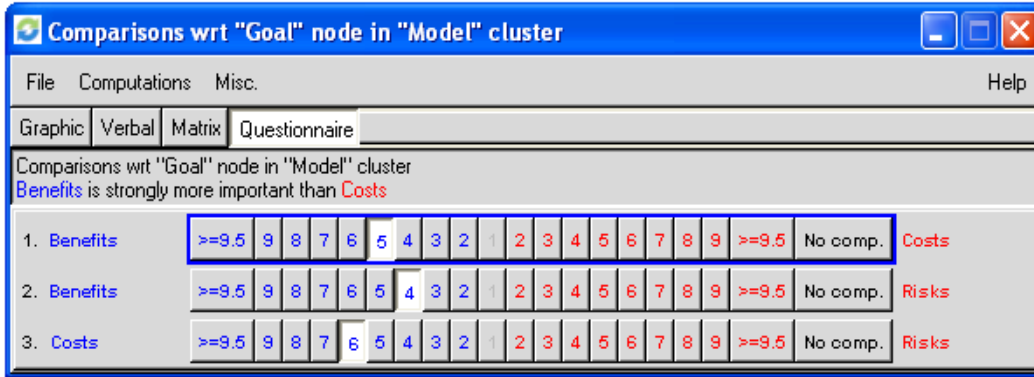


Figure 12: Comparison with respect to goal node in the model cluster.

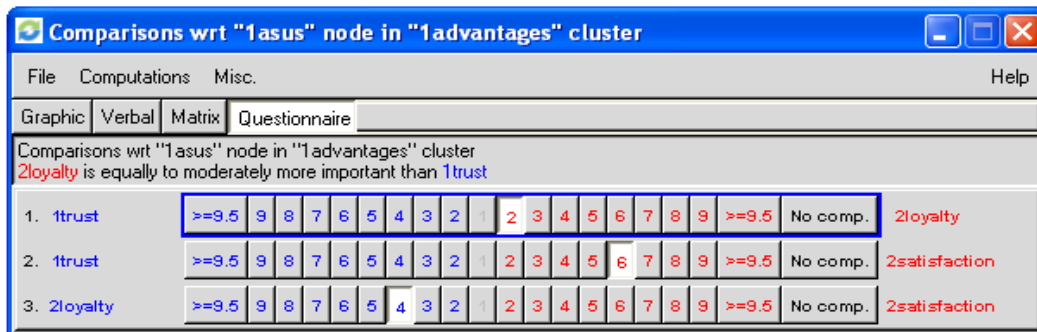


Figure 13: Comparison with respect to ASUS in advantage cluster.

#### 4.2.1 Results:

Figures 14, 15 and 16 shows the results of criteria under Benefits, Costs and Risks. Figure 14 shows that on the basis of benefits INTEL is the best supplier as compared to other two suppliers. However, figure 15 shows that ASUS is better when cost is considered. If we compare on the basis of Risk then once again ASUS is superior to other two suppliers.

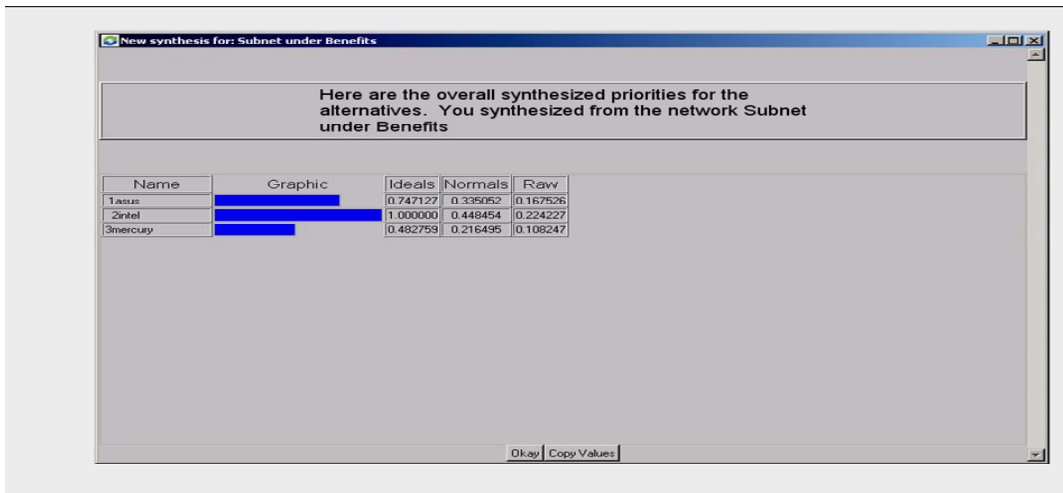


Figure 14: Showing overall priorities under Benefits.

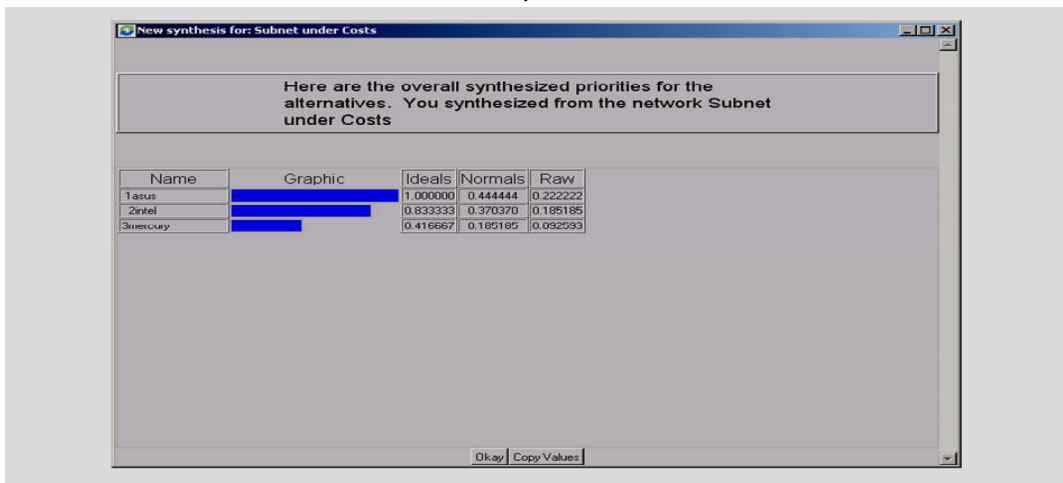


Figure 15: Showing overall priorities under Costs

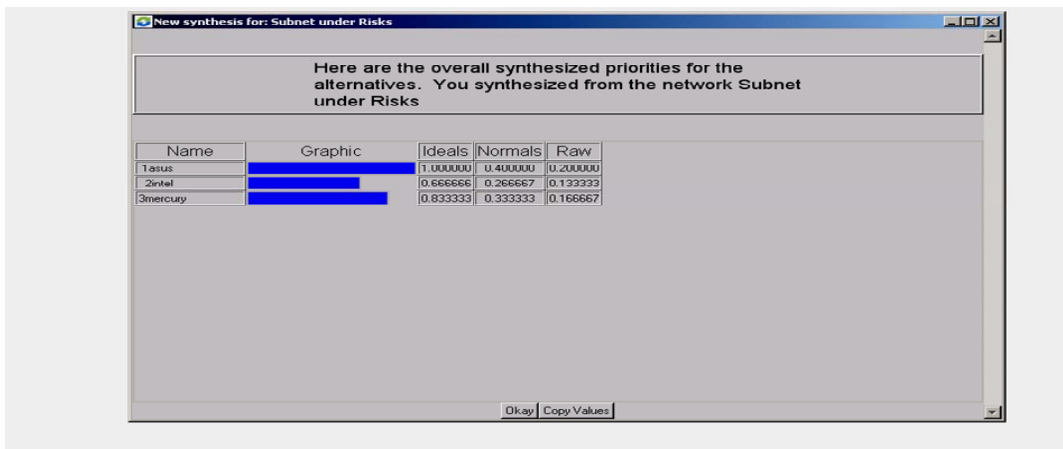


Figure 16: Showing overall priorities under the Risk.

Figure 17 shows the final result of selecting the best supplier. It is seen from this figure that **INTEL** is superior to other two supplier based on the criteria and the weightage considered for each criteria in this project. This result is for this specific supply chain. The decision may change if the criteria or its weight are changed.

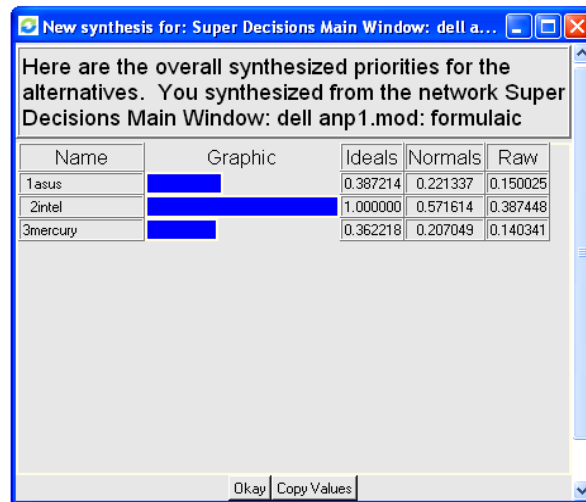


Figure 17: Final result of selecting the best supplier

**4.2.2 Sensitivity Analysis:** In general terms sensitivity analysis investigates the robustness of a study when the study includes some form of Mathematical modeling. Sensitivity analysis tries to identify what source of uncertainty weights

more on study conclusion. Thus sensitivity analysis is the study of how the Variation in the output of a mathematical model can be apportioned, qualitatively or quantatively to different sources of variation in the input of a model. In this case also we perform the sensitivity analysis of the results obtained by ANP method. Figure 18 shows the sensitivity analysis of the model. The figure shows when cost criteria is 0.5 on the x-axis keeping all other three criteria constant then INTEL outperforms other two suppliers. And when the cost criteria are 0.0369 then ASUS and INTEL have almost equal priority. This is highlighted in figure 19.

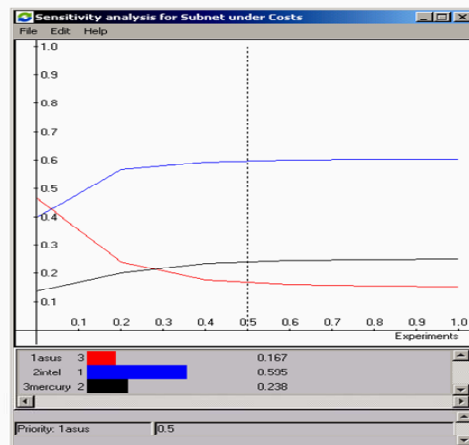


Figure 18: Showing the Sensitivity Analysis for Cost.

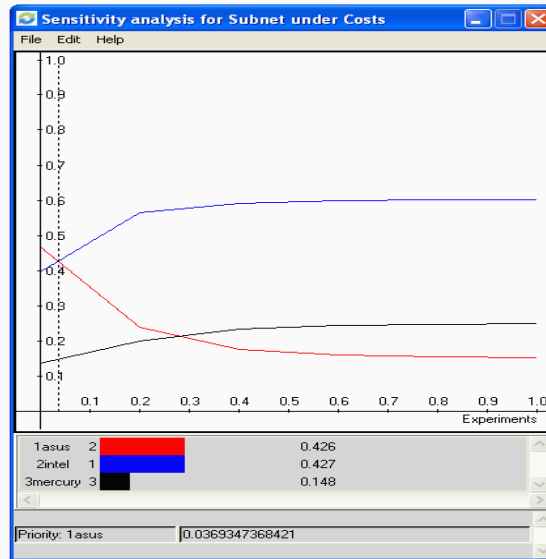


Figure 19: Showing the Sensitivity Analysis for Cost.

## 5 Comparison of AHP and ANP Results:

Analytic Hierarchy Process (AHP) is a special case of the ANP. Both the AHP and the ANP derive ratio scale priorities for elements and clusters of elements by making paired comparisons of elements on a common property or criterion. Although many decision problems are best studied through the ANP, as we can also interlink various criteria in addition to the subcriteria, which is not possible in AHP.

- With the AHP analysis ASUS is the best ALTERNATIVE.
- With the ANP analysis INTEL is the best ALTERNATIVE.

Since in ANP, we have also interlink various criterias in addition to the subcriteria. Hence ANP gives more accurate and refined result of a problem as compared to AHP.

## 6. Discussion and Conclusions

The framework that was used in this study could serve as one of the tools for making a strategic decision. The criteria and attributes that were used in the model focused on supplier selection strategy and requirements. The model is capable of taking into consideration quantitative, and multiple dimensions of information into the analysis, a powerful and necessary characteristic for any strategic evaluation. The framework represents only one set of possible relationships. A variation in the attributes or organizational strategies can also be made to this model. In an actual implementation of this framework, the number of attributes will be specific to the organization that applies this model.

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