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A Prototype AHP System for Contractor Selection Decision

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<http://dx.doi.org/10.5772/64425>

Abstract

Contractor selection process is generally believed to be marred with lots of bias in most developing nations, which sometimes leads to incompetent contractor being selected because it is based mainly on human experience and feelings. In particular, in a culturally biased country like Nigeria where most contractors' selection process is not based on performance but rather on whom you know, not paying attention to important factor/criteria but rather on selfish personal gains, which directly or indirectly affect the public in different forms could have some negative effects on projects. The failure of managers to be objective in decision-making in regard to contractor selection has great consequences for the government as well as corporate organizations in terms of cost incurred, delivery time, and impact on the general welfare of the people. Hence, there is a need for managers to be interested in the selection of contractors, suppliers of materials, equipment, and services as failure or inefficiency on the part of the contractor that could affect the well-being of the people negatively and damage the performance rating of the government. Developing an appropriate model to address the problem of poor contractor evaluation would, no doubt, be a great relief in the selection of contractors. This chapter presents a prototype system for contractor evaluation decision.

Keywords: prototype, AHP system, contractor, selection, evaluation, decision

1. Introduction

For many years, there has been a great concern on the number of abandoned projects by different tiers of government in several developing nations. This is because subjective judgments such as political patronage, selfish interest, friendship, and satisfying the interest of some highly placed people were often used when contracts are to be awarded. In cases where projects were

even completed, the qualities of work done were found to be far below standard. These authors thus believe that the most prudent process of selecting the most qualified contractor for any government or organization project is through contractor prequalification based on some criteria, sub-criteria, and alternatives (choice of the most qualified contractor). Even when the right model for contractor selection is developed, most people find the implementation of such model on the computer difficult to get the desired results on the ratings of the criteria, sub-criteria, and alternatives.

This chapter addresses how an analytic hierarchy process (AHP) model developed for contractor selection can be implemented on the computer to get the right ratings using some existing computer software programs. Thus, the main objective of this chapter is to illustrate how an AHP model for contractor selection can be implemented on personal computer using existing software.

2. Literature review on contractor selection

The past literature reveals that there are three types of tender that are practiced in Europe [1], Malaysia, and Nigeria [2]. These are:

- Open tender: where all interested contractors submit tenders.
- Restricted/selected tender: where only invited or selected contractors are allowed to bid. Reference [3] reveals that most organizations in the UK and many other countries adopt this method.
- Negotiated tender: where client consults the chosen contractors and negotiates the terms of contract with them.

According to Ref. [4], the tendering process begins with the analysis to ensure that tender specification meets with end users' needs, followed by contractor selection which starts with tender invitation and ends with contract award and contract monitoring. In Nigeria, contractors are invited to submit tender submission through advertisement in major national publications [5]. Thereafter, contractors who have interest in bidding for the tender as per the conditions contained in the advert will purchase the tender documents and provide the information required as stated in the advert. The completed documents are then submitted to the tender board not later than the submission deadline stated in the advert. Information contained in the tender documents includes the instruction to bidders, the conditions under which contract will be awarded, and the necessary technical specifications of the contract. Contractors are also expected to submit the bill of quantities and list of forms that have been submitted. At the end of the closing date of the advert, all tenders are pulled together and opened. Tenders received are then assessed so as to decide on the most eligible contractor to be awarded the contract. Even with this well-laid-down procedure, contracts are often awarded to unqualified contractor.

According to Ref. [6], assessment is the most crucial stage in the tendering processes due to the fact that it contributes to the decision in choosing the most qualified contractor to be

awarded the contract. However in all these processes, hardly is any decision support system (such as models) used in making a decision by most organization, that is, decision is often based on subjective comparisons.

3. Prototype development

In order to illustrate the implementation of a prototype system for contractor selection based on AHP methodology, a case study of the selection of a contractor for the infrastructure

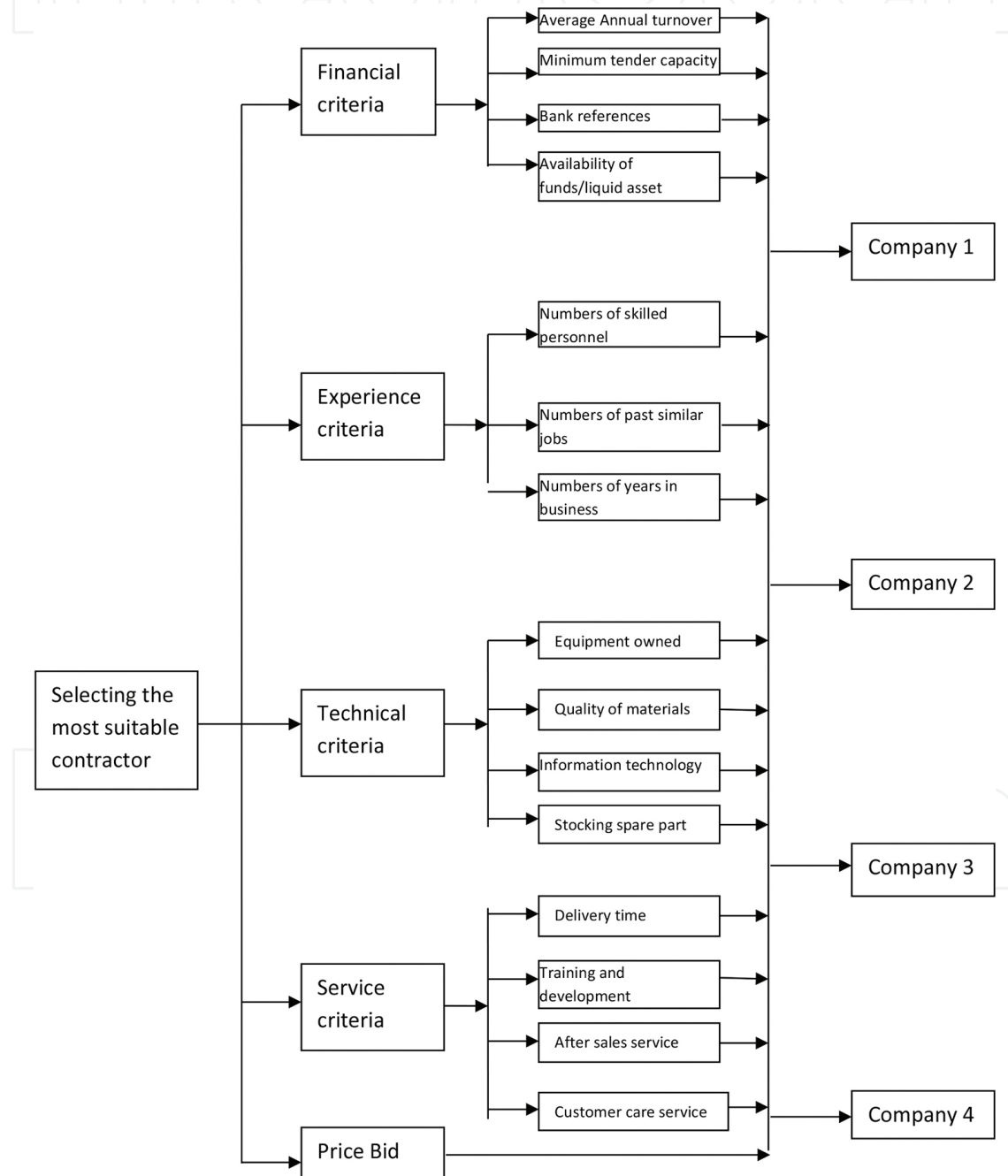


Figure 1. Hierarchical structure of the AHP model.

development of the National Centre for Technology Management (NACETEM), an agency of the Federal Ministry of Science and Technology in Nigeria, is used as illustration. NACE-TEM is an agency vested with the mandate of training and developing middle- to high-level manpower and conducting policy research in the areas of science, technology, and innovation management for all tiers of government and the private sector.

To select the most suitable contractor for the infrastructural development of the agency based on AHP methodology, information was gathered from all the departments in the organization on the selection process and later carefully analyzed so that standard criteria and sub-criteria could be established and later adjusted with respect to the general goal. Once the problem has been defined as selecting the best contractor, the process starts with the design of the prototype system, which includes designing the system architecture and identifying the implementation and operational framework. The knowledge acquired through the knowledge acquisition process is represented in the prototype in four main steps:

1. Developing the hierarchy as shown in **Figure 1**
2. Pairwise comparison of criteria and sub-criteria
3. Synthesis of the AHP model
4. Measuring inconsistency in decision-maker's judgments

Judgment of the results by the expert (i.e., tenders board) and evaluation of the prototype are carried out, whereby the effectiveness of the software and hardware is checked. If the results or findings from the evaluation require some improvement, the prototype is modified and redesigned as appropriate.

4. Evaluation of the prototype system

The aim of the evaluation is to determine the usability and functionality of the finished prototype. This would be achieved through interviews and questionnaire administered to the experts (tenders board).

5. Operation of the prototype system

The developed prototype system provides a decision support tool to decision-maker by aiding in the selection of the most qualified contractor to upgrade internet infrastructure. The system allows for input from users in the decision-making process. The prototype system:

- provides a clear and structured framework of implementation of the decision-making process, which assists the user in the selection of the most qualified contractor to upgrade the internet infrastructure based on the criteria and sub-criteria included in the AHP model

- supports the decision-making process by providing simplified information on the selection process; and
- assists the decision-maker to take rational and justified decision through graphical reports and sensitivity analysis

Goal	Criteria	Sub-criteria	Alternatives
Level 0 (1 node)	Level 1 (5 nodes)	Level 2 (15 nodes)	Level 3 (4 nodes)

5.1. System requirement

The prototype system operates on personal computer running window XP or later version for smooth operation. However, it can still work with lower versions of window XP. It requires Expert Choice 11 which is the current version, Microsoft Office 2003 or later version (MS Word, MS Excel, MS Access, etc.) to be installed. It is also advisable to have relatively large memory and storage capacity (say, 1 G of RAM and 100 G of hard disk size).

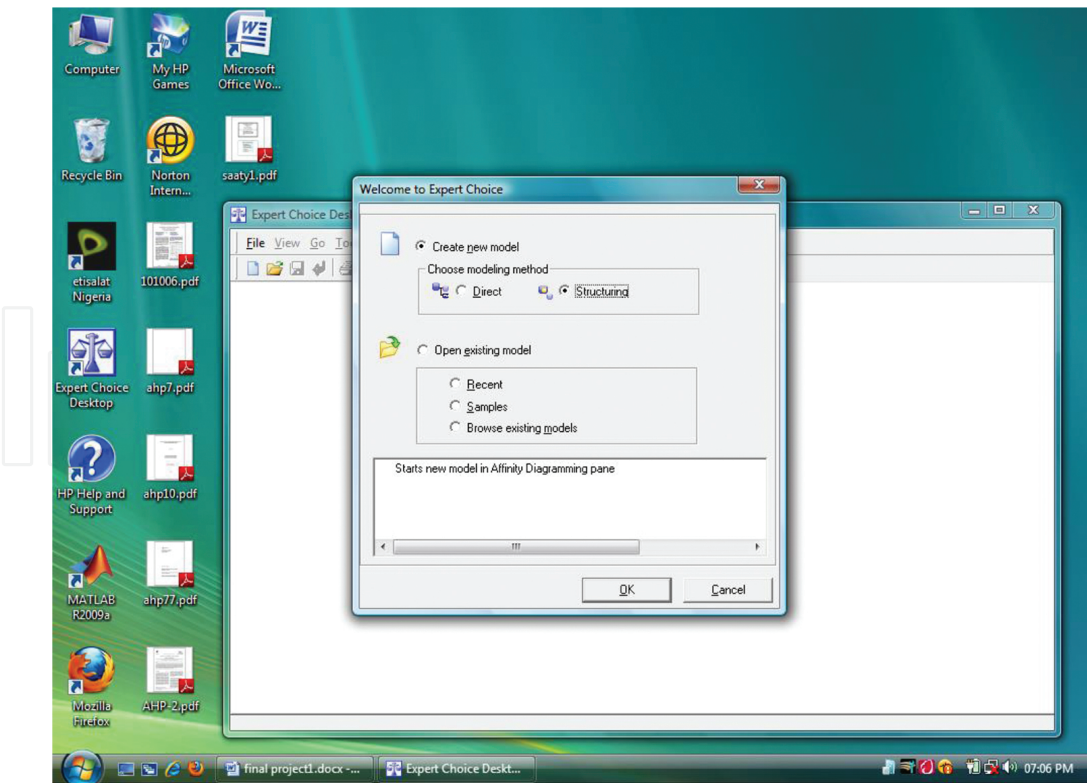


Figure 2. Expert Choice welcome window view panel that is divided into three major panes.

5.1.1. Starting the prototype system

The prototype system is stored as an Expert Choice file called “contractor selection.ahpz” and held in directory with specific name, e.g., “C:\users\Ola-dotun\document\contractor selection.ahpz.”

To start the application, click on Start button on the desktop, then select All Programs, and click on Expert Choice or double-click on Expert Choice from the desktop to open the application (**Figure 2**); if one is designing a fresh model, then click on Create New Model, select Structuring, and click Ok. The application will display a dialog box where you can type the name of the model and save to Start Building a New Model.

- 1. *The Tree View pane.* The hierarchy displayed in this (contractor selection model) consists of five main criteria and fifteen sub-criteria with the goal being to select the best contractor for the upgrading of internet infrastructure (**Figure 3**).
- 2. *Alternative pane.* The list of alternative is displayed here. That is, the four companies that is being considered in handling the project.
- 3. *Information document pane.* This includes information on operating the system and links to other information document files, which may be of importance for easy understanding of the system.

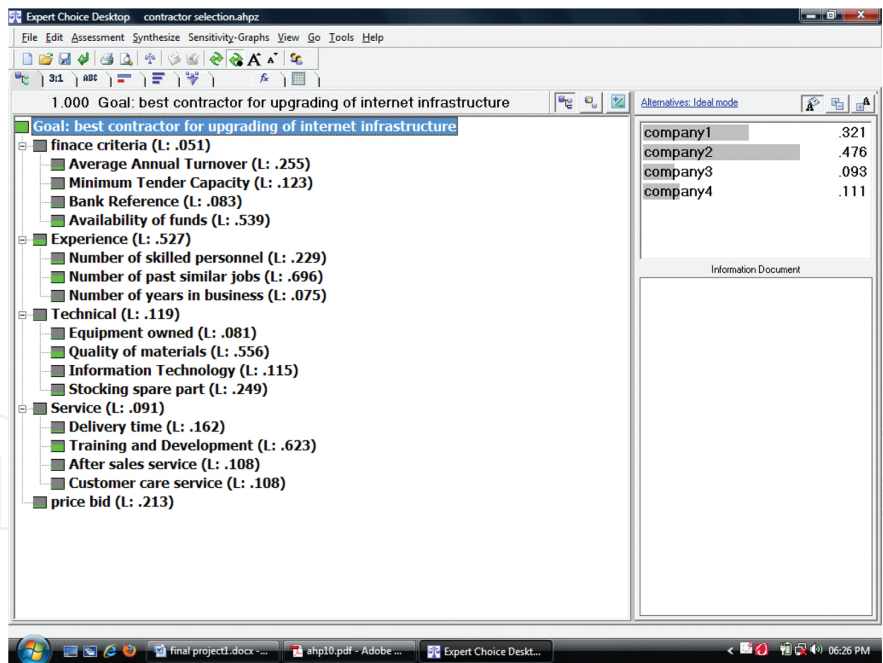


Figure 3. Contractor selection system using Expert Choice.

5.1.2. Assigning judgment in pairwise comparison

One of the main strengths of AHP is the use of pairwise comparisons to derive accurate ratio scale priorities. The pairwise comparison process compares the relative importance, prefer-

ence, or likelihood of two elements with respect to each other. A judgment is made as to which is more important and by how much. Judgment about the relative importance of criteria is made with respect to the parent node in the hierarchy (either the goal or a higher-level criterion). Judgments about the relative preference of alternatives are made with respect to each criterion. You can make judgments/pairwise comparisons starting with the goal and working down to the alternatives (top-down), or you can make judgments about the alternatives before making judgments about the objectives (bottom-up). The bottom-up approach is usually better because the insights you gain about the trade-offs among the alternatives will help in making judgments about the importance of the objectives [8]. Expert Choice provides judgment in three different forms, namely pairwise numerical comparison, pairwise verbal comparison, and pairwise graphical comparison (**Table 1**).

Subjective judgment of preference	Rating
If criterion (a) is extremely more preferred than criterion (b)	9
If criterion (a) is very strongly to extremely preferred than criterion (b)	8
If criterion (a) is very strongly preferred than criterion (b)	7
If criterion (a) is strongly to very strongly preferred than criterion (b)	6
If criterion (a) is strongly preferred than criterion (b)	5
If criterion (a) is moderately to strongly preferred than criterion (b)	4
If criterion (a) is moderately preferred than criterion (b)	3
If criterion (a) is equally to moderately preferred than criterion (b)	2
If criteria (a) and (b) are equally preferred	1

Source: Saaty [7].

Table 1. Rating of pairwise comparison of a pair of criteria and sub-criteria using AHP preference scale.

For instance, the user makes judgments about the preference of a contractor (company) with respect to the criterion, “average annual turnover.” The steps to take include:

1. Click on the sub-criteria average annual turnover under the first set of criteria in the hierarchy “Finance.”
2. From the Menu, select Assessment; then select Pairwise. You will be taken to the verbal comparison window (the default) (**Figure 4**). Since you are comparing the alternatives (companies) with respect to the objective, average annual turnover, the judgment type is “preference.” **Figure 4** shows the judgments.
3. The judgment that best reflects the subjective feeling of the decision-maker base on the pairwise comparison is selected by dragging the verbal scale indicator up or down to the appropriate position. **Figure 4.** shows that company 2 is strongly more preferred to company 3 when the criterion of average annual turnover is considered. In the case where company 3 is more preferred to company 2, the indicator is dragged down toward company 3 and stationed at the appropriate level of preference.

The lower cell is called the active cell and contains the numerical (in black) representations by which the elements (i.e., companies) displayed along the rows are more preferred to those displayed along the columns in a matrix format, based on the comparison of average annual turnover criterion, while any judgment shown in red indicates that the column element is preferred to the row element.

4. The above process (step 3) is repeated until all the companies have been compared, by pairing them in twos, with respect to their average annual turnover.

Inconsistency: Possible errors and actual inconsistency in judgment are identified by the inconsistency measure shown in the bottom-left cell of the matrix. For the decision-maker's judgment to be reasonably consistent, the inconsistency ratio must be less than 0.1. The decision-maker should only change an inconsistent judgment if he truly feels that the initial comparison was in error.

5. Recording judgments and calculating priorities.

When all judgments have been made, one is prompted to record judgments and carry out necessary calculation. Select YES so as to return to the Model View.

The priorities of alternatives with respect to average annual turnover are automatically computed and displayed in the Pane of the Model View. **Figure 5** shows the priorities of the companies with respect to "average annual turnover."

In a situation where the resulting relative priorities do not reflect the decision-maker's feelings, the pairwise comparison process is repeated. These can be achieved either by using the verbal mode or by switching over to either the graphical mode or numerical mode. To obtain the right result, the user should click on the tab of one of the three pairwise comparison tabs. The user then selects the mode that he feels will make the most sense and later uses the selected mode to obtain the judgment for the current set of criteria (or sub-criteria) being compared.

6. Processes 1–5 are repeated until all comparisons for sub-criteria (15 nodes) and criteria (5 nodes) have been made.
7. Assignment of judgment.

To assign judgment to the sub-criteria against criteria as well as to criteria against the goal, the user (decision-maker) must change the comparison type from "preference" to "importance."

To change the assessment type:

- Select assessment.
- Select type.
- Select importance.

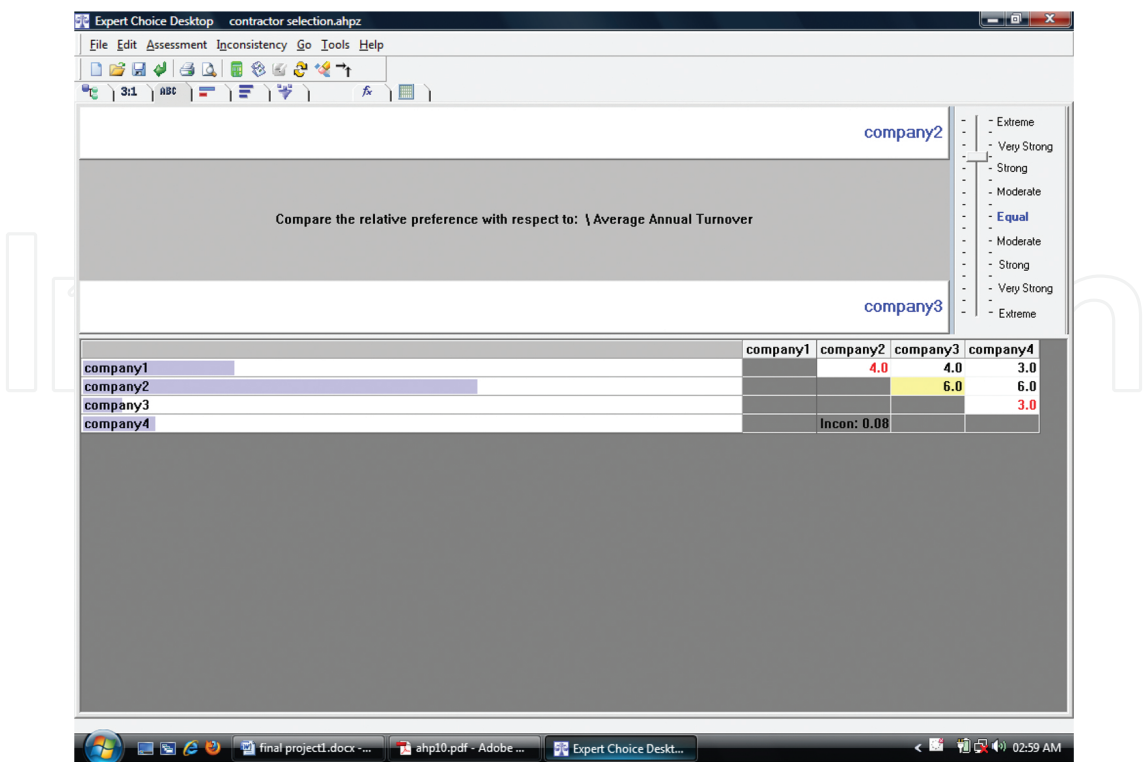


Figure 4. The verbal comparison window.

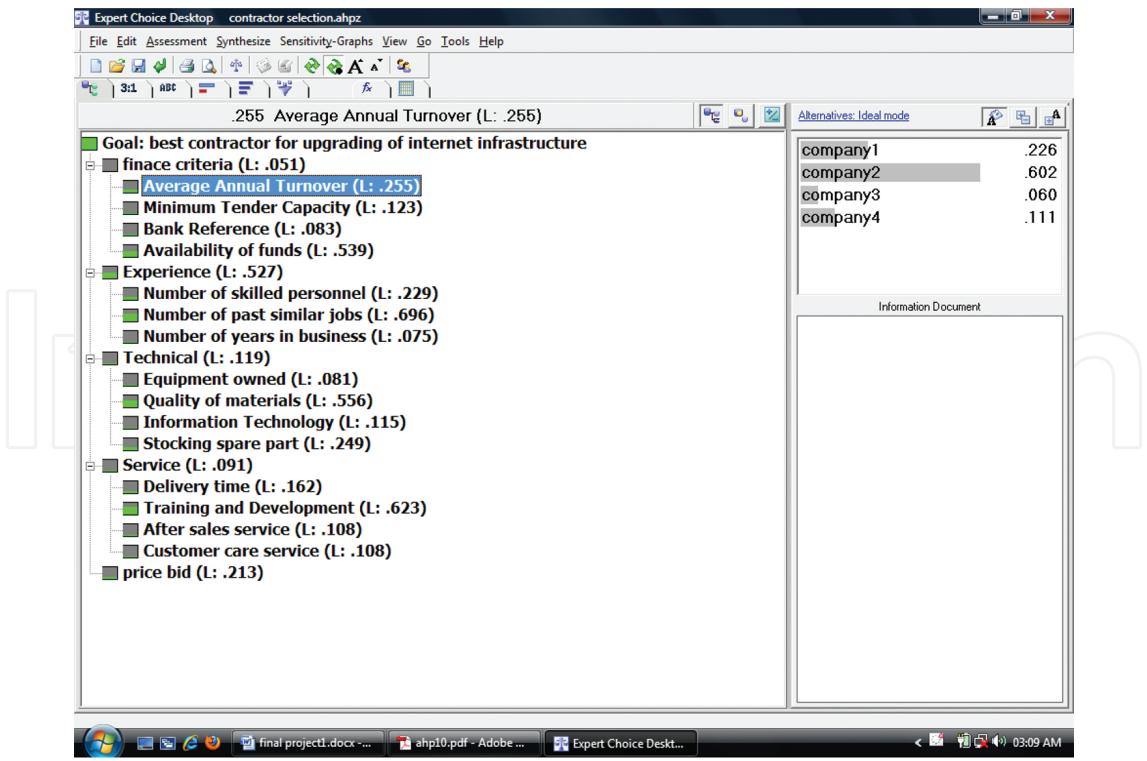


Figure 5. Derived priorities of the alternatives with respect to average annual turnover.

5.1.3. Synthesizing and measuring inconsistency

Tree View in both graphic and numerical form.

To examine the synthesis, select Synthesis, with respect to the goal to produce the display shown in **Figure 6**, while **Figure 7** shows the Synthesis window displaying the charts.

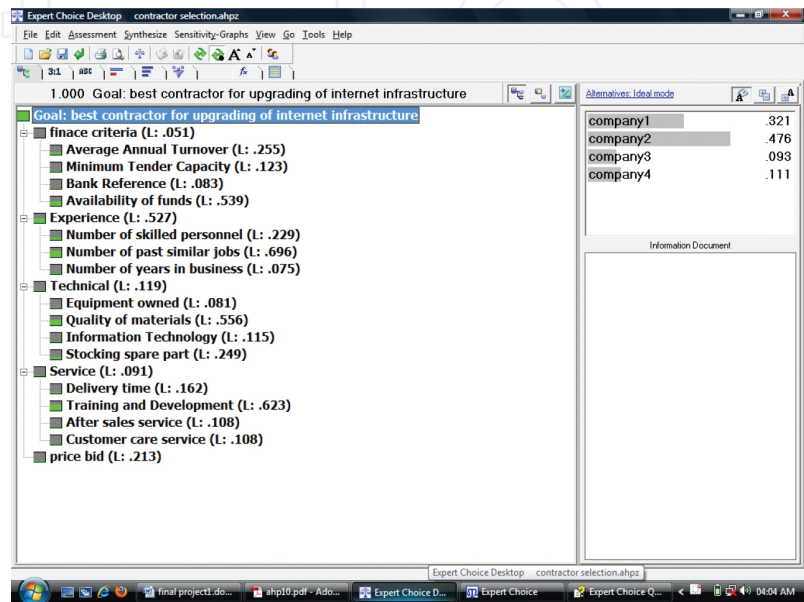


Figure 6. Model View showing the synthesized results with respect to the goal.

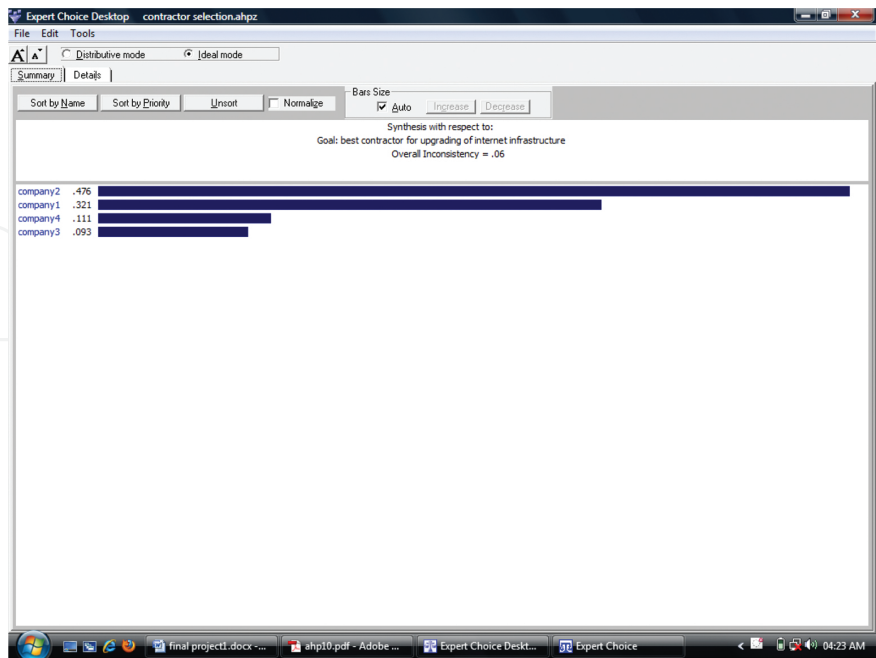


Figure 7. Synthesis window.

In Expert Choice, the “Distributive Mode” and “Ideal Mode” are two synthesis methods that can be used to derive the results. Distributive Synthesis is used when the users are interested in prioritizing alternatives from which they may pick more than one alternative, while the ideal Synthesis should be used when one is interested in only one alternative, and the remaining alternatives are no longer relevant. The difference in results obtained using the ideal or distributive synthesis modes is usually negligible and more of theoretical than practical interest.

5.1.4. Sensitivity analysis

Expert Choice provides tools for performing sensitivity analysis. Sensitivity analysis displays how the alternatives change priorities if there is a change in the importance of the criteria or sub-criteria graphically. Starting with the goal node, sensitivity analysis displays the sensitivity of the alternatives with respect to all the criteria below the goal. Since the AHP model in use as illustration has more than three levels, sensitivity analysis can also be performed from the nodes below the goal to show the sensitivity of the alternatives with respect to the criterion and sub-criterion [8]; and according to Ref. [9], when performing a sensitivity analysis, the user may change the priorities of the criteria and observe how the priorities of the alternatives would change.

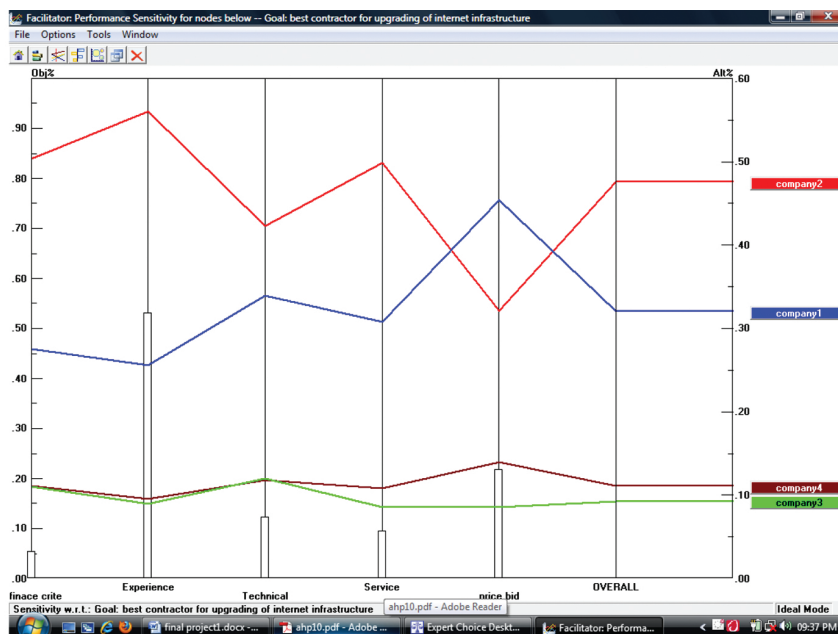


Figure 8. Graph of sensitivity analysis.

There are five types of sensitivity analysis that can be carried out in Expert Choice, namely, performance, dynamic, gradient, head-to-head, and two-dimensional plot. The first three are often used to perform the sensitivity analysis because you can dynamically vary them by dragging the objective bars.

To perform sensitivity analysis from Tree View, click on the goal or criteria or sub-criteria that you want to perform analysis on with respect to the alternatives, and select sensitivity graph, then click the type of sensitivity analysis you want to perform.

- Performance sensitivity: This analysis displays how the alternatives perform with respect to all criteria; that is, it shows how each alternative is prioritized relative to other alternatives when considering each criterion as well as the overall goal (**Figure 8**). By dragging each criterion bar up and down, we can temporarily alter the relationship between the alternatives and their criteria.
- Dynamic sensitivity: This is concerned with how the choice of priorities of the alternatives changes when the priority of one criterion is varied. Dynamic sensitivity analysis is used to dynamically change the priorities of the objectives to determine how the changes affect the priorities of the alternative choices. By dragging the priority bar of the objective on the left column of **Figure 9** toward the left or toward the right, the priorities of the alternatives also change along the right column. In a situation where the decision-maker feels that a criterion is of greater importance than originally indicated, the priority bar of the objective is dragged toward the right to increase the priority of the criterion; while if the criterion is of less importance than originally indicated, the decision-maker drags the priority bar of the objective toward the left to decrease the priority of the criterion so as to assess the impact on the alternatives (**Figure 9**).

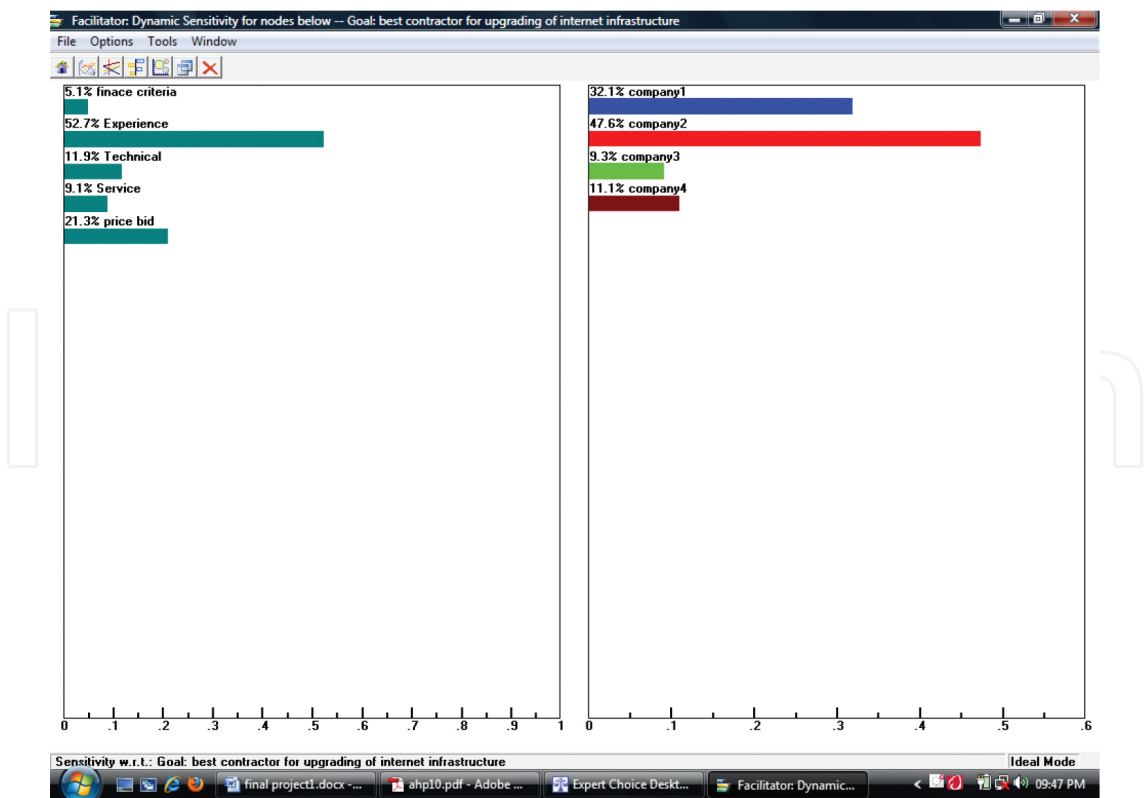


Figure 9. Graph of dynamic sensitivity analysis.

- Gradient sensitivity: This displays the composite priority of the alternatives with respect to the priority of a single criterion. **Figure 10** displays the priorities of the alternatives (contractors) with respect to a criterion, one at a time. The priority of the selected criterion is represented by the vertical solid line and be read where the line intersects the X-axis. However, the priorities of the alternatives are read along the Y-axis. In order to change the priority of the objective, the vertical solid bar is dragged toward either the left-hand side or right-hand side as one desires, and the new priority of the objective is displayed along the dotted bar.
- Head-to-head sensitivity: Displays how any of the two alternatives compare with respect to each criterion and the goal.
- Two-dimensional sensitivity: Displays how alternatives perform with respect to any of the two criteria.

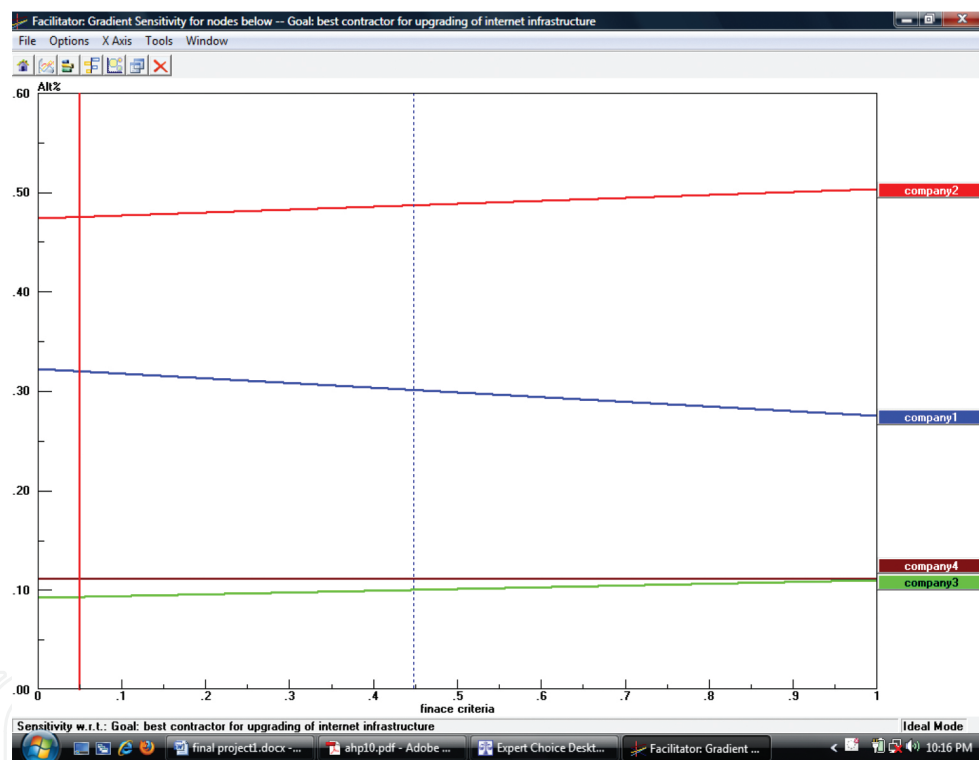


Figure 10. Graph of gradient sensitivity analysis.

6. Conclusion

This chapter simply demonstrates how an AHP model for contractor selection can be implemented on the computer to get the desired results. However, this does not foreclose the use of the procedure enumerated in the chapter for AHP model on other issues. Once the criteria, sub-criteria, and alternatives for any AHP model are clearly identified and stated, the step-by-

step use in this chapter can be adopted to generate the needed result. It is believed that the procedure enumerated in the chapter will lessen the difficulty encountered by students and users of AHP models in getting results.

The managerial implication of the chapter lies in the fact that once the correct AHP is developed by them or a professional decision support system (DSS) expert based on internally and externally generated ideal information from experts saddled with the decision problem, implementation of the model to arrive at the right decision becomes easy.

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