Quantitative Evaluation of IS Applications

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Summary
The adoption and implementation of IS applications amongst organizations is becoming widely evident. Several organizations across the different industries are now embracing IS applications as a mean to remain competitive and efficient. Implementation of IS applications however requires huge IT investments, which constitute an extremely important part of the e-business suite in many organizations. There have been some earlier attempts by researchers to develop systematic and quantitative approaches and tools for the evaluation of the vendors in general, regardless of the nature of the system/application. In this paper will primarily focus on assessing and measuring the vendor by developing a quantitative model. A review will first need to be conducted to scan through the previous related literature in the area of the quantitative evaluation of information systems. A model was formulated for the quantitative evaluation for vendor selection using Analytical Hierarchal Process with expert choice. The paper is concluded by a survey with some local organizations in order to understand their adoption level of quantitative evaluation methods, and also to substantiate and validate the proposed model.

Key words:
Analytical Hierarchal Process (AHP), IS application, Quantitative Evaluation, Vendor Selection.

1. Introduction

Information systems (IS) provide a lot of opportunities for the organizations to improve their daily operations through the integration between the organization's systems. While the old information systems were focused on applications within the internal enterprise. E-business systems are a part of those systems that are applied to deal with the internal and external enterprise [2]. The increased complexity of IS, and the lack of uncertainty and unpredictability associated with its benefits and costs, lead to the need for evaluation paradigm that helps the organizations to improve the impact of IS investment [3].
The evaluation of IS success or effectiveness is critical to our understanding of the value and efficacy of IS management actions and IS investments thus IS Success measurement has been one of the key issues of concern both in IS management practice and research [1].
One of the main challenges that organizations face today resides in their ability to choose the most correct and consistent alternatives in such a way that strategic alignment is maintained. Given any specific situation, making the right decisions is probably one of the most difficult challenges for science and technology.
Selecting the suitable vendor is always a difficult task for any organization. Vendors have varied strengths and weaknesses, which require careful assessment by the organization before ranking, can be given to them.
In this Paper we focused on assessing and measuring the vendors. In this way we proposed a model using the Multi Attribute Decision Making (MADM) approach that used in decision making systems. This approach has many methods like Simple Additive Weighting (SAW) and Analytical Hieratical Process (AHP). In this paper we used the second methods to propose our evaluation model, Then we applied this model for two case studies for selecting a vendor for IS application in ministry of finance to measure the success and efficiency of this model. In our evaluation model we used expert choice software to give us the quick result.
This paper is organized as follows: section 2 describes background and the related work. Section 3 describes the Analytical Hierarchal Process (AHP). Section 4 describes the model implementation. Section 5 describes the case studies.

2. Related work

In many problems in the world we need to combine quantitative measures including financial measures with qualitative concerns. Analytic hierarchy process (AHP) is to analyze multi-criteria decision problems involving both quantitative and qualitative criteria.
In [4] they proposed a model using the ratings method using the AHP to enhance the security of the information system for the organization. This rating method is to specify the optimal allocation of a budget for the enhancing. In this ratings method, the organization should define the criteria and sub-criteria to be used in AHP in order to define the weights for each of these criteria and sub-criteria. Finally a score is determined for each alternative.
In [5] they proposed ArchDesigner as a "systematic approach for facilitating the architectural design of distributed software applications". Their approach is to determine the best combination of design alternatives that

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satisfy stakeholders' quality goals and project constraints using optimization techniques.
In [6] they presented a model for evaluation and selection of IT projects. The model is hybrid and draws on Multi Attribute Decision Making (MADM) and Multi Objective Decision Making (MODM) to evaluate those attributes that cannot be quantified. Their model was applied at Penrose Mills organization to select the best IT project. Theu made a combination between MADM and MODM to use both qualitative and quantitative decision attributes, for the projects.

3. Analytic Hierarchy Process (AHP)

3.1 Definition

The Analytic Hierarchy Process (AHP) is a multi-attribute decision making (MADM) method which helps the decision maker in the complex problem with multiple mixed and subjective criteria (e.g. vendor ranking, projects selection). The main advantage of AHP is using the permitting a hierarchical structure to build the criteria, this advantage provides a better picture on specific criteria and sub-criteria when the decision maker assigning the weights [7].
AHP was developed in 1971 when Saaty worked for the USA Department of Defense. Its development was based on linear algebra, operational research and psychology. AHP has the ability to use a hierarchy structure to systemize a complicated question and to divide the decision making criteria into several ways; furthermore, different aspects are used to divide a question into different hierarchies so as to make a complicated bigger question into a smaller question, then AHP procedures are used to evaluate their relative importance and integrations respectively so that a final solution can be found out AHP is a common theory of ration scale measurement, which based on psychological and mathematical foundations. AHP has been applied on wild filed for multi-attribute problems. More than 1500 academic researches described this method, suggesting applications, presenting critics and improvement [8][9].

3.2 AHP fundamental elements

The fundamental elements of the AHP are [9]:

Goal

The main objective to be reached.

Alternatives

Set of choices to be ranked and ordered.

Criteria

A criterion represents one property to be evaluated for each alternative. The alternatives should be compared using these criteria.

Hierarchy

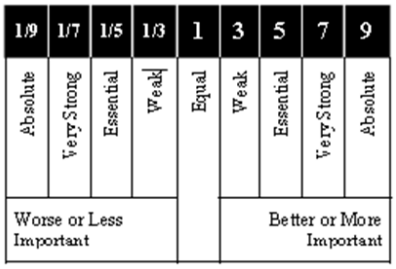
The set of criteria is organized in hierarchic levels forming a tree. The hierarchic representation of criteria describes the priority for each level (lower and higher).

Pair-wise Comparison

In this element, pair-wise matrixes are filled for each criterion. Comparisons are made pair- pair indicating witch alternative is preferable in relation to another.

Fundamental Scale

Pair-wise matrix values use the Saaty Fundamental Scale [9] (see figure 3.1).



If we are comparing two criteria we must assign a number from the previous scale to define how much a criterion is important than other. The scale is ranging from 1 to 9.

4. The Model Implementation

4.1 Introduction

The use of AHP instead of another multi-criteria technique is due to the following reasons:

1. Quantitative and qualitative criteria can be included in the decision making.
2. A large quantity of criteria can be considered.
3. A flexible hierarchy can be constructed according to the problem.

One of the main challenges that organizations face today resides in their ability to choose the most correct and consistent alternatives in such a way that strategic alignment is maintained. Given any specific situation,

making the right decisions is probably one of the most difficult challenges for science and technology.
In this research, we did case studies using AHP to measure the effectiveness of the model for supporting the decision maker in Saudi Arabia. We have chosen (Ministry of Finance-MOF) in Saudi Arabia.
The vendor selection process would be simple if only one criterion was used in the decision making process. However in many situations, MOF have to take account of a range of criteria in making their decisions. If several criteria are used then it is necessary to determine how far each criterion influences the decision making process, whether all are to be equally weighted or whether the influence varies accordingly to the type of criteria.
The analytic hierarchy process (AHP) has found widespread application in decision making problems, involving multiple criteria in systems of many levels. This method has the ability to structure complex, multi-person, multi attribute, and multi-period problem hierarchically. The AHP can be very useful in involving several decision-makers with different conflicting objectives to arrive at a consensus decision The AHP method is identified to assist in decision making to resolve the supplier selection problem in choosing the optimal supplier combination.

4.2 Methodology

The objectives of this works were to develop AHP model for vendor selection. The first step is establishing the criteria that used for assessing the vendors. We have defined these criteria based on survey for a number government organizations as well as coordination with e-government program (Yesser). The second step according to the AHP method, the interview was filled out to evaluate the criteria. Interviews were conducted with decision makers (Stakeholders). The resulting survey was mailed to the selected stakeholders and they were requested to include any additional criteria that seemed important. Third step we have selected a two projects to apply the AHP. Fourth step was interview with three decision makers to have completed mathematical calculations, comparisons of criteria and allocating weights for each criterion in each level is performed. Fifth step was applying a software program for easily using and calculating the vendor selection model which is (Expert Choice) then the results and priority weight for each vendor are extracted. Sixth step was to return to stakeholders and conducting a questionnaire survey to measure their satisfaction with AHP technique and the possibility of using this technique in the future.
In this study AHP was applied on selecting the MOF's vendor for:

Case 1: ERP Project.
Case 2: Portal Project.

4.3 Criteria Development

Criteria developments are divided into two parts: main-criteria, sub -criteria development and Structure the hierarchical model.
Main-criteria, Sub -criteria development
Determining the criteria for the vendor selection is the first step in developing the model. In general, any organization has its own criteria for selecting a vendor. Here we tried to define general criteria that can be used at any type of information systems application that a study has been made together with the Finance, Strategy Planning and Project Management areas on the criteria to be used. We have defined these criteria based on survey for a number government organizations as well as coordination with e-government program (Yesser). These criteria can be expandable based on requirements. The following six (criteria from C1-C6) and twenty-two (sub-criteria from SC1-SC22) has been accepted as shown in the table 4.1 below.

Table 4.1: criteria and sub-criteria for vendor selection

Criteria and sub-criteria for vendor selection	Abbrev
Technical capabilities and expertise of vendor	C1
Experience in developing similar systems (not less than 10 years)	SC1
Vendor must have an experience not less than 3 years in development using the same technology that he offered	SC2
The company is specialized in IT	SC3
The company directly implement the project	SC4
The level of the technical staff to be assigned to complete work	C2
Level of qualifications of the staff	SC5
The level of qualifications for the course project	SC6
The full-time technical staff and the appropriate number of members	SC7
Methodology	C3
Details and clarity of the methodology	SC8
Understanding the scope of work	SC9
The suitability of the methodology for the scope of work	S10
Using the international standards	SC11
Work plan	C4

How realistic the timescales set for the main and secondary stages of the project	SC12
The suitability of the work plan for the proposed methodology	SC13
Implementation the first phase (12 months = 1. 9 months = 2. 6 months = 3)	SC14
General technical requirements	C5
The importance of change management during implementation	SC15
Clear acceptance criteria for each stage of the project	SC16
Taking into account the security and protection requirements	SC17
The extent and clarity of the solution submitted by the vendor and the integration between the systems (Integration).	SC19
The Testing	C6
A configuration Test	SC20
A documentation Test	SC21
A Unit and System Test	SC22
A Quality Assurance	SC23

Structure the hierarchical model

The hierarchal representation for the criteria is shown in the figure 4.1 below using Visio

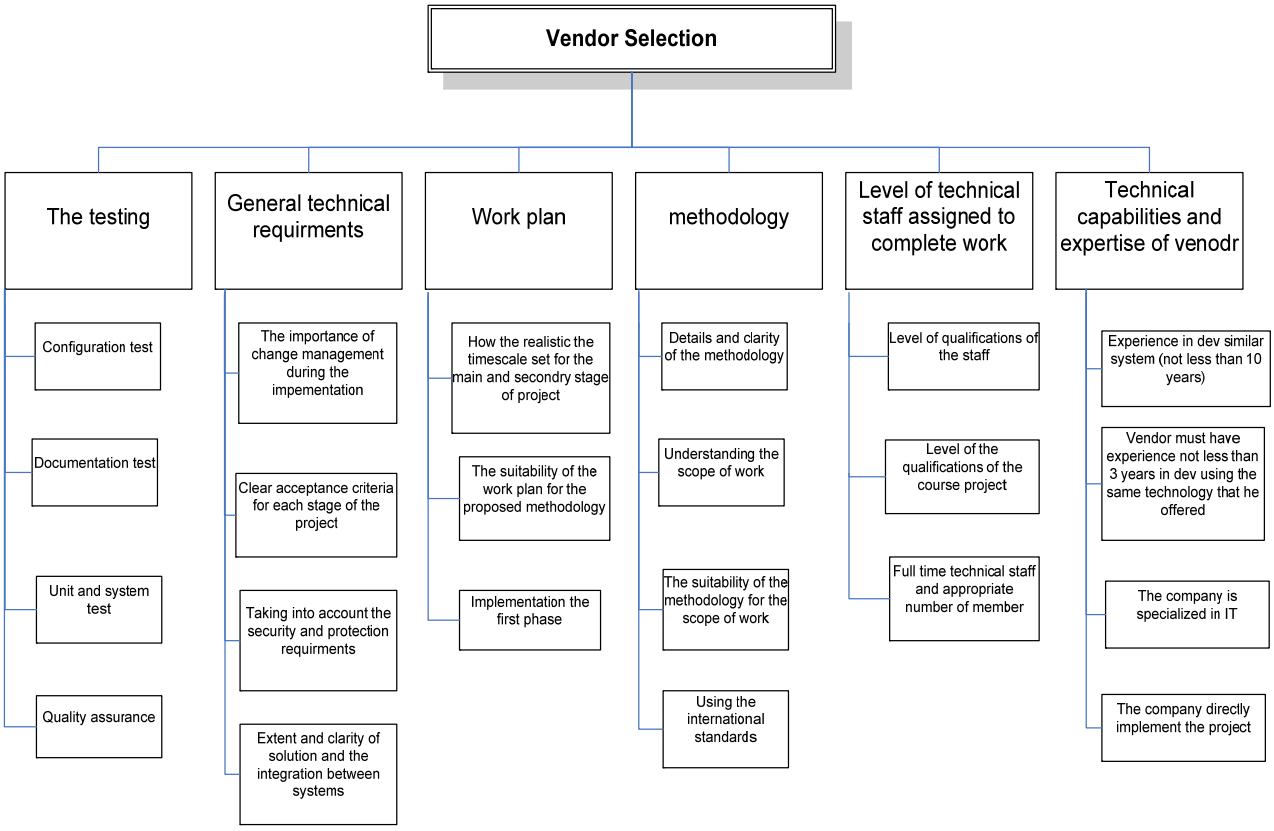


Figure 4.1: Hierarchy of Criteria for Vendor Selection

Using Expert Choice the hierarchal view of the criteria is shown in the figure 4.2 below.

4.4 Scale of Pair-wise Comparisons

The relative importance scale between two alternatives suggested by Saaty is the most widely used. Attributing values that vary from 1 to 9, the scale determines the relative importance of an alternative when compared to another alternative, as we can see in Table 2 below.

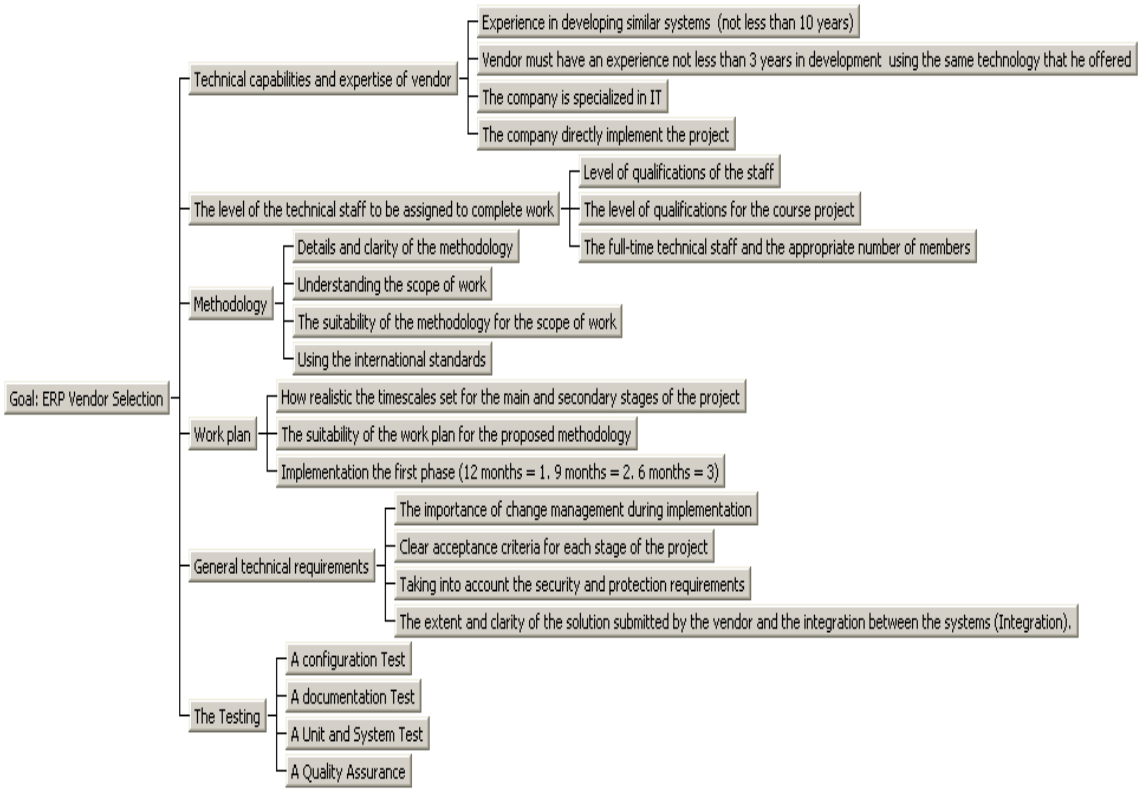


Figure 4.2: Hierarchy view of Criteria using expert choice

Table 4.2: Fundamental Scale suggested by Saaty of Pair-wise Comparisons

The Fundamental Scale of Pair-wise Comparisons		
Intensity of importance	**Definition**	**Explanation**
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2,4,6 and 8 can be used to express intermediate value		

5. The case studies

5.1 Case 1: ERP vendor selection.

In this case (1) the ministry of finance is looking to select the best vendor to implement the ERP system based on the requirements that determined before. In this case the goal is ERP vendor selection. The criteria must be evaluated in pairs so as to determine the relative importance between them and their relative weight to the global goal.

Pair-wise comparing the Criteria with respect to the Goal

After the hierarchy has been established, the criteria must be evaluated in pairs so as to determine the relative importance between them and their relative weight to the global goal. To incorporate their judgments about the various elements in the hierarchy, decision makers compare the elements two by two. We will begin with the six criteria in the second row of the hierarchy. The Criteria will be compared as to how important they are to the decision makers, with respect to the goal.

In order to interpret and give relative weights to each criterion, it is necessary to normalize the previous

comparison matrix. The normalization is made by dividing each table value by the total column value. The AHP software uses mathematical calculations to convert these judgments to priorities for each of the six criteria. One more step can be made here. We know how much the priority of each criterion contributes to the priority of the goal. The figures 5.1 and 5.2 below show the result after applying expert choice.

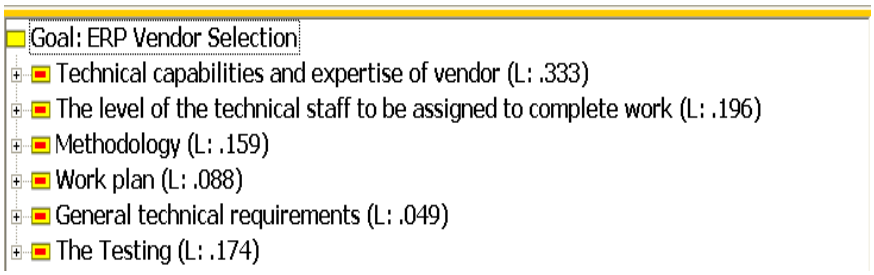


Figure 5.1 Expert choice pair-wise comparisons for the main criteria respect to the goal

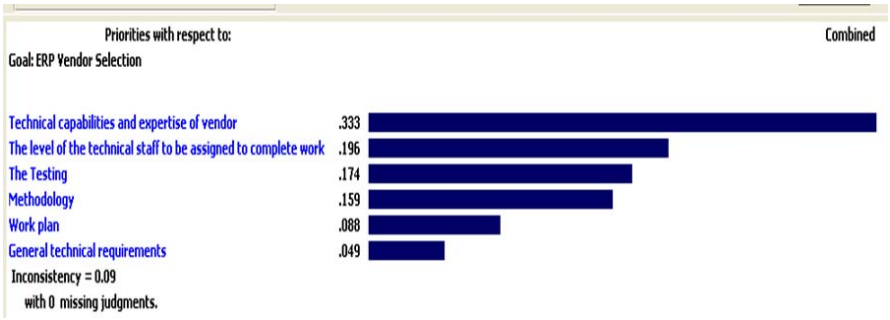


Figure 5.2 Expert choice pair-wise comparisons for the main criteria respect to the goal

Pair-wise comparing the sub-Criteria with respect to the criteria

It is necessary to evaluate the criteria's relative weights for the second level of the hierarchy (sub-criteria). This process is executed just like the step to evaluate the first level of the hierarchy (Criteria).

The results of the previous comparisons are shown in the figures below after applying expert choice:

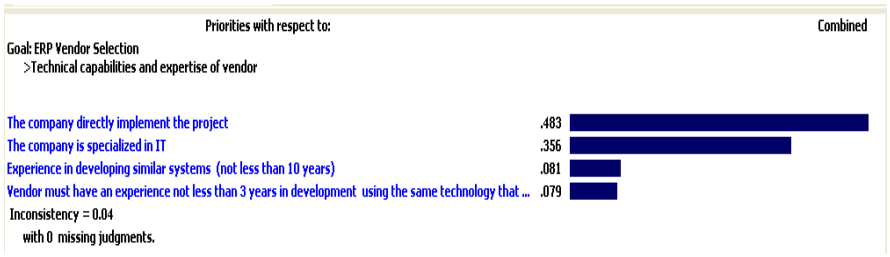


Figure 5.3 – Priority results for the technical capabilities and expertise of vendor criteria

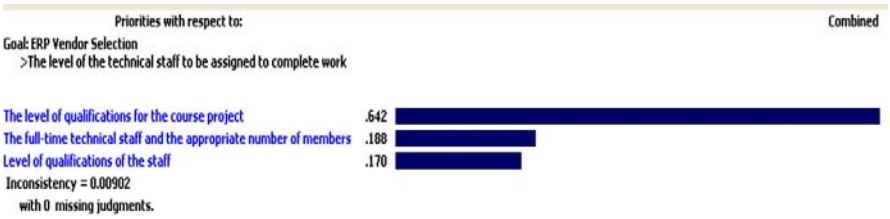


Figure 5.4 – Priority results for the level of the technical staff to be assigned to complete work criteria

Figure 5.5 – Priority results for the Methodology criteria

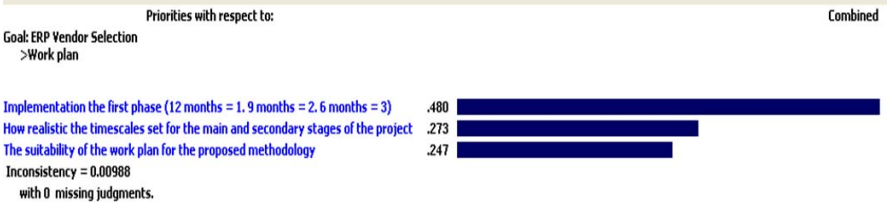


Figure 5.6 – Priority results for the Work Plan criteria

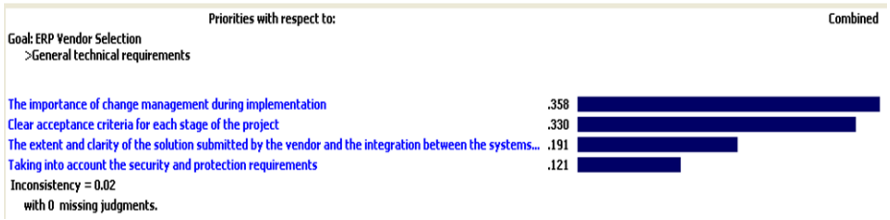


Figure 5.7 – Priority results for the General technical requirements criteria

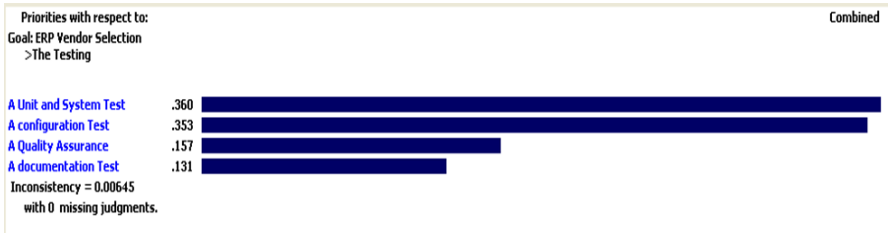


Figure 5.8 – Priority results for the Testing criteria

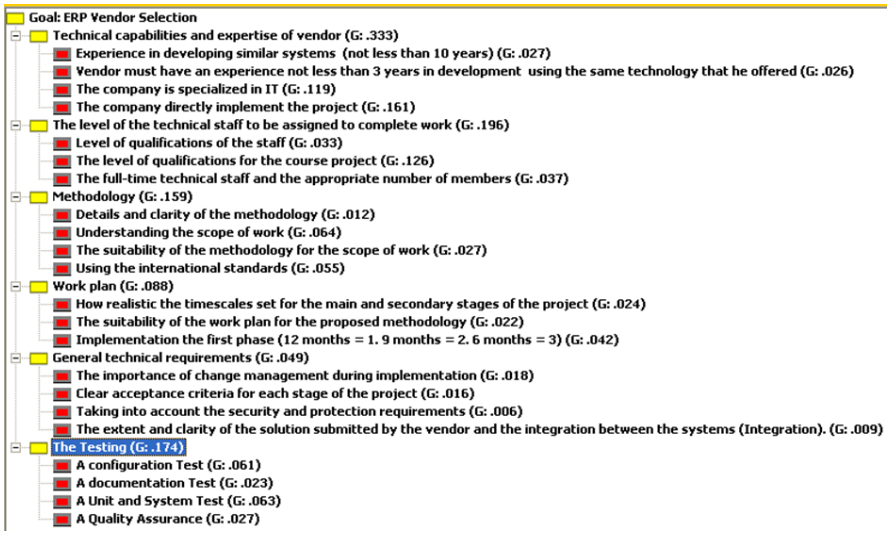


Figure 5.9 – Hierarchy of criteria for the ERP vendor selection with global priorities for each criterion

Evaluating the Vendors

After having structured the tree and established the priority criteria, it is now possible to determine how each one of the vendor fits the chosen criteria. In the same manner that the criteria prioritization has been made, the vendors are pair-wisely compared considering every established criterion.

After weighting the AHP model for determining priority weight for alternatives and testing the model, the third structured interview was designed and modifies. This interview collects the weightings of alternatives to identify the best vendor. In this step, to determine the priority weight for alternatives, the competitive rivals that are actually the vendors who are supposed to be used for MOF were compared. After finding the local weights of each alternative, the global weights of each alternative in each level can be calculated. The global weights evaluation of each alternative can be obtained through multiplying the global weights of sub sub-criteria by the local weights of each alternative.

In this case for our MOF organization, two (2) different Vendors have been identified and must then be prioritized. The vendors are:

1. TATA.
2. SBM.

Note: the model can accept any number of alternatives.

In order to apply AHP, the decision makers from MOF organization have compared two (2) vendors taking into consideration every one of the twenty-two (22) established criteria.

Case 1 Results

Based on the global priority, weights of each alternative can be evaluated and summarized. The summaries of overall attributes are shown in below. It can be noted that among the two given vendors, vendor "TATA" has the highest weight. Therefore, it must be selected as the best vendor to satisfy the goals and objectives of the MOF. Figure 5.10 and 5.11 show the final score of each vendor s' results and ranking. As can be seen, vendor TATAs' score of (0.795) is greater than the SBM's score (.205).

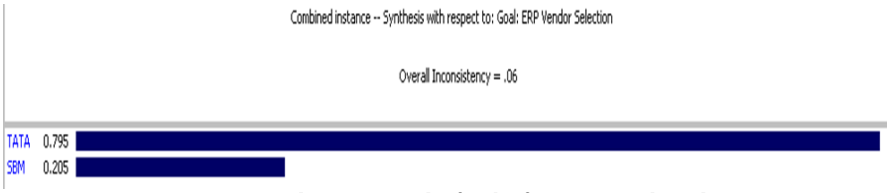


Figure 5.10 – Final priority results for the for MOF vendor selection

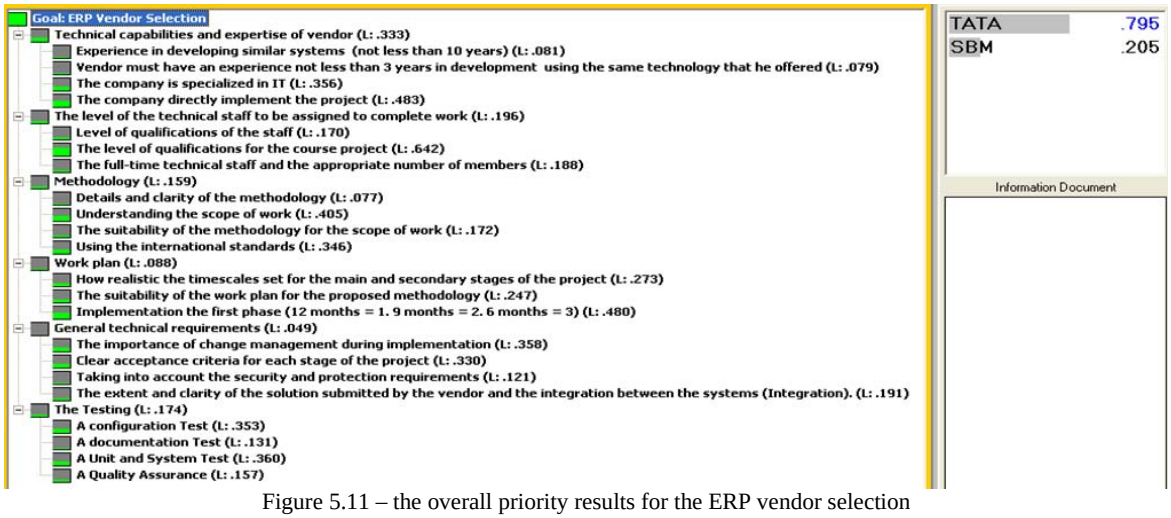


Figure 5.11 – the overall priority results for the ERP vendor selection

5.2 Case 2: Vendor selection for MOF's Portal.

In this case (2) the ministry of finance is looking to select the best vendor to implement its portal based on the requirements that determined before. In this case the goal is portal vendor selection. The criteria must be evaluated in pairs so as to determine the relative importance between them and their relative weight to the global goal.
Pair-wise comparing the Criteria with respect to the Goal
As we said before (case 1) the criteria must be evaluated in pairs so as to determine the relative importance between them and their relative weight to the global goal.

In order to interpret and give relative weights to each criterion, it is necessary to normalize the previous comparison matrix. The normalization is made by dividing each table value by the total the total column value. The AHP software uses mathematical calculations to convert these judgments to priorities for each of the six criteria. One more step can be made here. We know how much the priority of each Criterion contributes to the priority of the goal.
The figures 5.12 and 5.13 below show the result after applying expert choice.

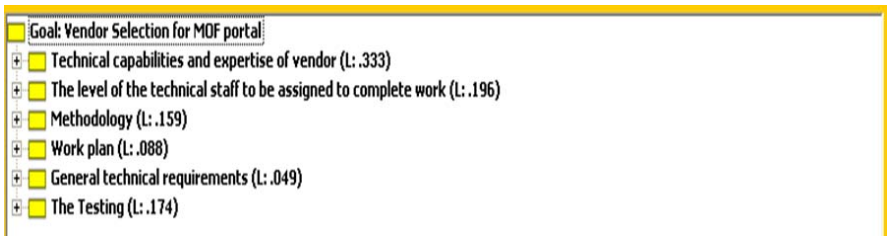


Figure 5.12 Expert choice pair-wise comparisons for the main criteria respect to the goal

Pair-wise comparing the sub-Criteria with respect to the criteria

As we said in previous case study 1 it is necessary to evaluate the criteria's relative weights for the second level of the hierarchy (sub-criteria). This process is executed just like the step to evaluate the first level of the hierarchy (Criteria).
We also have to know how much the priority of each Sub-criterion contributes to the priority of its parent.
The results of the previous comparisons are shown in the figures below after applying expert choice:

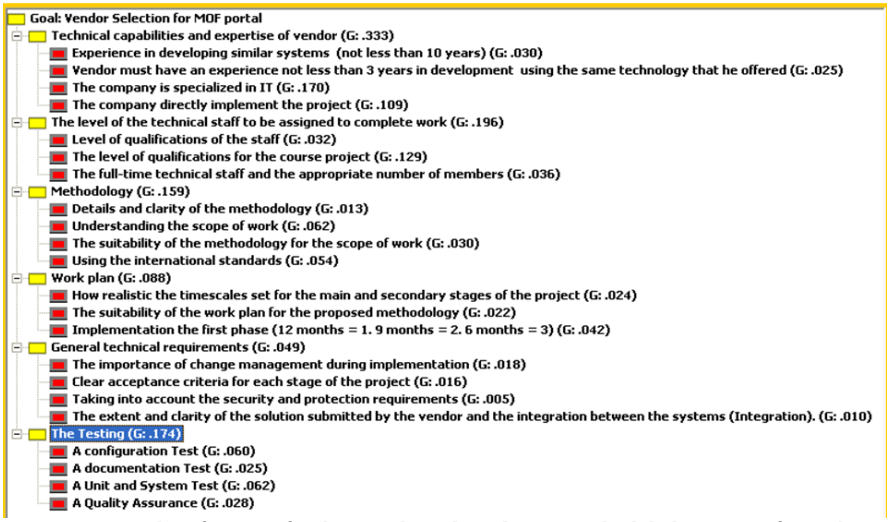


Figure 5.13 – Hierarchy of criteria for the Portal vendor selection with global priorities for each criterion

Evaluating the Vendors

As we said in case 1 it is now possible to determine how each one of the vendor fits the chosen criteria. In the same manner that the criteria prioritization has been made, the vendors are pair-wisely compared considering every established criterion.

After weighting the AHP model for determining priority weight for alternatives and testing the model, the third structured interview was designed and modifies. This interview collects the weightings of alternatives to identify the best vendor. In this step, to determine the priority weight for alternatives, the competitive rivals that are actually the vendors who are supposed to be used for MOF

were compared. After finding the local weights of each alternative, the global weights of each alternative in each level can be calculated. The global weights evaluation of each alternative can be obtained through multiplying the global weights of sub sub-criteria by the local weights of each alternative.
In this case for our MOF organization, three (3) different Vendors have been identified and must then be prioritized. The vendors are:

1. Netways Company.
2. Sure Company
3. Saudi Company for Software Development (SCSD)

In order to apply AHP, the decision makers from MOF organization have compared three (3) vendors taking into consideration every one of the twenty-two (22) established criteria.

Case 2 Results

Based on the global priority, weights of each alternative can be evaluated and summarized. The summaries of overall attributes are shown in below. It can be noted that among the three given vendors, vendor "netways" has the highest weight. Therefore, it must be selected as the best vendor to satisfy the goals and objectives of the MOF. Figure 5.14 and 5.15 show the final score of each vendor s' results and ranking. As can be seen, vendor "netways"s' score of (0.480) is greater than the SCSD's score (.302) and Sure (0.218).

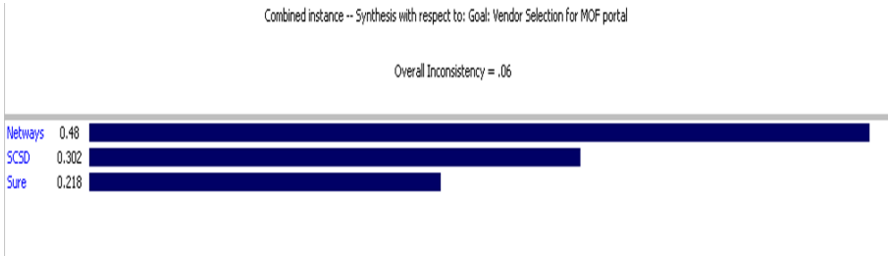


Figure 5.14 – Final priority results for the for MOF vendor selection

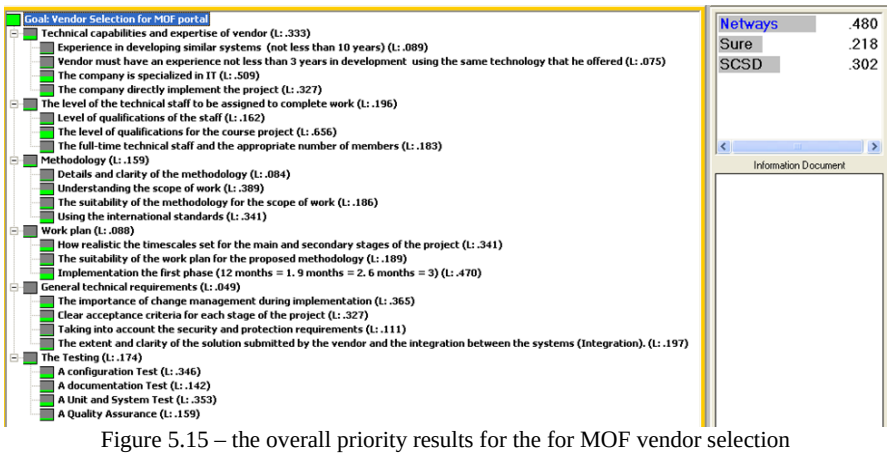


Figure 5.15 – the overall priority results for the for MOF vendor selection

The figure 5.16 below shows the expert choice screen that used to enter the evaluation of the criteria and sub-criteria and vendors for the three stockholders pair-wisly.

5.3 validating the usefulness of the approach

In this section I have conducted a questionnaire survey to the selected stakeholders to measure their satisfaction with AHP technique and the possibility of using this technique in the future in their decisions. The questions were:

1. Do you think AHP is useful in decision making?
2. Do you prefer to use AHP or Traditional way? Why?
3. As a decision maker, what are the key issues in using AHP?
4. What are the key strengths in using AHP?
5. From your point of view what is your evaluation for using AHP in decision making? (Your evaluation should be in percentage from 100%).

The responses from the stakeholders were similar and comparable to some extent. For question (1) all the responses were (Yes) this means the AHP technique is

useful and easy to use and understand for the decision makers.

For question (2) all the responses prefer to user (AHP) for several reasons some respondents stated that instead of shaping a decision in mind then walk toward it, AHP give the chance to break down the issue to its smallest items and then based in your preferences and priorities you will find yourself reaching to the decision not because you like it as in traditional way but because you really need based in your priorities and preferences. And some respondents said because it gives more accuracy to comparison analysis.

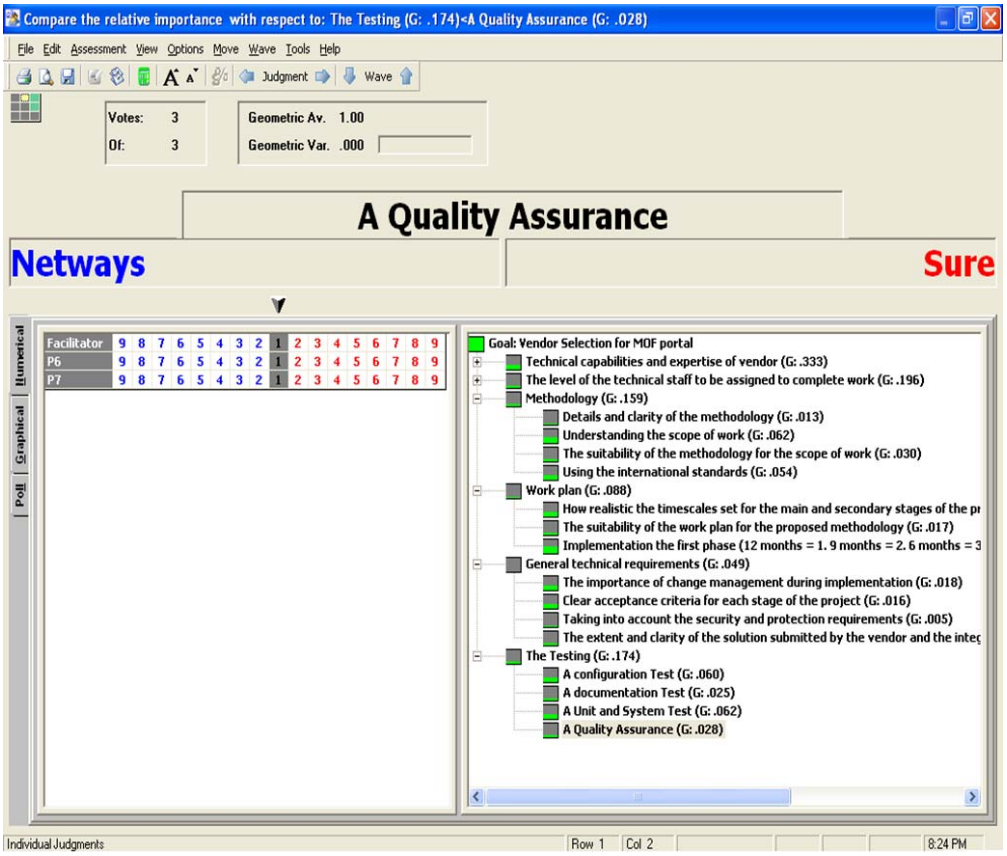


Figure 5.16 – the expert choice screen for entering the pair-wise comparisons for the three stockholders for vendor selection for MOF's portal.

For question (3) some respondents said the key issue is powerful technique it provides in managing complex problems when human factors exist with diversity in their specializations, poisons, and perceptions. AHP take its power from that side since it is give enough analysis to break down the issue to the level understood by each person and meet their expectation regarding the issue itself. And other respondents said you need to do a baseline for each item and weight to give a real comparison.

For question (4) some respondents said the key strengths in using AHP are using matrix comparison to compare different items in relation to each other. Other respondents said the key strength was its structured technique that based on levels, measures.

For question (5) all respondents gave a percentage of 90%.

6. Conclusions and Key findings

6.1 Key findings

1. AHP has highly praised from the stakeholders.
2. AHP is a useful decision aid method in the sense that it would help the decision-maker to make his decision using its advice without totally overriding the initial, tentative, choice.
3. AHP is used to create an improved problem understanding and to support communication among a group of decision makers with little interest in the details of deriving numerical results.
4. The decision makers have understood that both the structure of the hierarchy and the criteria weights need

to reflect the set of decision alternatives and their differences.

5. The reliability of AHP is very high as it detects top and least priorities. These observations suggest that AHP has been probably an adequate support decision tool in many decision problems.

6. Using the two case studies we have shown that AHP is useful in assisting the decision-making process, especially when the problem incorporates a dominant criterion.

7. AHP give the chance to break down the issue to its smallest items and then based in your preferences and priorities you will find yourself reaching to The decision not because you like it as in traditional way but because you really need based on your priorities and preferences.

8. Based on the stakeholders point of view AHP is easy to understand and easy to use because it just needs a few days to get the result instead of weeks with the traditional way while they evaluate the vendors.

9. Decision makers in MOF looking to use AHP in their future work for the decisions that contain qualitative and quantitative approach and need to be a accurate and fast.

6.2 Conclusions

Decisions that need support methods are difficult by definition and therefore complex to model. A trade-off between prefect modeling and usability of the model should be achieved. It is our belief that AHP has reached this compromise and will be useful for many other cases as it has been in the past.

AHP has been attracting the interest of many researchers mainly due to the mathematical features of the method and the fact that data entry is fairly simple to be produced. Its simplicity is characterized by the pair-wise comparison of the alternatives according to specific criteria. Its application to select vendors for MOF allows the decision makers to have a specific and mathematical decision support tool. This tool not only supports and qualifies the decisions, but also enables the decision makers to justify their choices, as well as simulate possible results.

The main contribution of the work was to develop a model for vendor selection process using AHP methods. The second contribution was to apply this model in some local organization to validate and measure the efficiency of the model.

Another important aspect is the quality of the evaluations made by the decision makers. For a decision to be the most adequate possible, it must be consistent and coherent with organizational results. We saw that the coherence of the results can be calculated by the inconsistency index. However, the inconsistency index allows only the evaluation of the consistency and regularity of the opinions from the decision makers, and not whether these opinions are the most adequate for a specific organizational context.

Finally, the developed model is tested using two case studies for vendor selection problems. The results show the model is able to assist decision-makers to examine the strengths and weaknesses of vendor selection by comparing them with appropriate criteria, sub-criteria. Also this model was welcomed by stakeholders and they decided to use it in future based on their responses on the questionnaire.

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