SELECTION OF ERP

ERP selection is a fundamental process in which different project components such as change management, business reengineering, and an ERP independent consultant, play a key role in identifying strong and weak points of your organisation.

The actual process of evaluating and selecting an ERP System is never the same for any two companies. Every company has their own unique internal conditions that make one company different from another one. Analytical Hierarchy Processing (AHP) is one of a method used for the selecting appropriate ERP package for a company.

Prior to the implementation, the system evaluation process must be executed to identify which ERP system is selected. The decision-making process is a critical point in the life cycle of an ERP system. Selection of the right ERP system requires careful consideration of multiple criteria and careful balancing between business requirements, technical characteristics, and financial issues. The process of selection ERP can be done easily with Analytic Hierarchy Process (AHP).

1. ANALYTIC HIERARCHY PROCESS (AHP)

Analytic Hierarchy Process (AHP) is a decision analysis approach developed by Thomas L. Satty in 1971. It is a methodology for multi-criteria analysis and decision-making, which enable decision makers to represent the interaction of multiple factors in complex situations.

AHP uses a hierarchy to structure a decision problem, which deconstructs the problem into its component elements, groups the elements into homogeneous sets and arranges them hierarchically. The objective of decomposition of the total problem into several levels is to enable pairwise comparisons of all the elements on a given level with respect to the related elements in the level just above. The solution process consists of three stages:

  i.   Determination of the relative importance of the attributes
  ii. Determination of the relative importance of each of the alternatives with respect to each attribute.
  iii. Overall priority weight determination of each of these alternatives

2. STEPS OF AHP ANALYSIS

The steps of the analysis are as follows:

1) Establishment of the Hierarchical Structure

The first step in the Analytic Hierarchy Process is to model the problem as a *hierarchy*. In doing this, participants explore the aspects of the problem at levels from general to detailed, then express it in the multileveled way that the AHP requires. As they work to build the hierarchy, they increase their understanding of the problem, of its context.

2) Weights between the Elements on Different Levels

The calculation of the weight between the elements on different levels is completed though the following four steps:

A. Establishment of Pair-wise Comparison Matrix:

The element comparison is conducted in this step. The parent element of an element on a lower level is used as an evaluation criterion for the pair-wise comparison.

B. Calculation of Priority Vector

Divided each comparison value by the sum of the values in corresponding fields for the aggregation of the rows; namely, the sum of the percentage each comparison value occupies in its corresponding row. An n x 1 matrix is acquired in this step.

C. Calculation of the Maximum Eigenvalue λmax:

Multiply the entire matrix with the acquired priority vector to produce an n x 1 matrix. Then divide this matrix by the priority vector to acquire unit vectors. Calculate sequentially the average of the unit vectors to acquire the maximum eigenvalue λmax.

D. Examination of Consistency:

During the pair-wise comparison, discrepancies might occur between the results of the comparison and the decision. The consistence ratio of Satty's AHP is used to examine the consistency of the entire matrix.

3. AHP HIERARCHIES

An AHP hierarchy is a structure consists of an overall *goal*, a group of options or *alternatives* for reaching the goal, and a group of factors or *criteria* that relate the alternatives to the goal. In most cases the criteria are further broken down into subcriteria, sub-subcriteria, and so on, in as many levels as the problem requires.

The hierarchy can be visualized as a diagram like the one below figure (8.1), with the goal at the top, the alternatives at the bottom, and the criteria filling up the middle. In such diagrams, each box is called a *node*. The boxes descending from any node are called its *children*. The node from which a child node descends is called its *parent*. Applying these definitions to the diagram below, the five Criteria are children of the Goal, and the Goal is the parent of each of the five Criteria. Each Alternative is the child of each of the Criteria, and each Criterion is the parent of three Alternatives.

The design of any AHP hierarchy depend not only on the nature of the problem at hand, but also on the knowledge, judgments, values, opinions, needs, wants, etc. of the participants in the process.

As the AHP proceeds through its other steps, the hierarchy can be changed to accommodate newly-thought-of criteria or criteria not originally considered to be important; alternatives can also be added, deleted, or changed.

4. ESTABLISH PRIORITIES

Once the hierarchy has been constructed, AHP is used to establish *priorities* for all its nodes. In doing so, information is elicited from the participants and processed mathematically. This activity is somewhat complex.

Priorities are numbers associated with the nodes of the hierarchy. By definition, the priority of the Goal is 1.000. The priorities of the Criteria (which are the children of the Goal) can vary in magnitude, but will always add up to 1.000. The priorities of the children of any Criterion can also vary but will always add up to 1.000, as will those of their own children, and so on down the hierarchy.
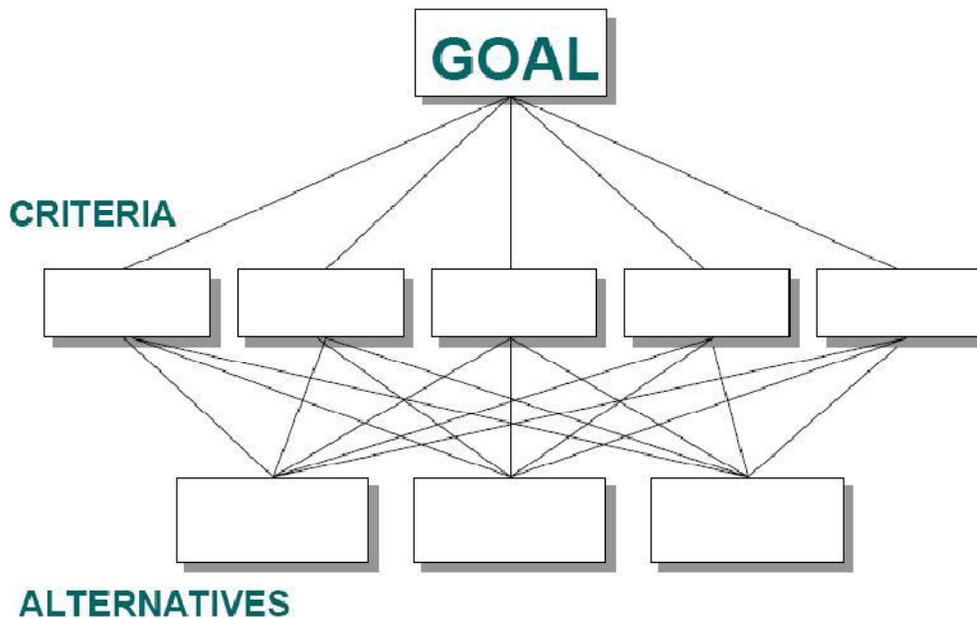

Figure 8.1: A simple AHP hierarchy

5. PAIRWISE COMPARISONS

To incorporate their judgments about the various elements in the hierarchy, decision makers compare the elements two by two. Every criteria is compared in pair with other criteria. The Criteria will be compared as to ***how important they are to the decision makers***, with respect to the Goal.

Each pair of items in this row will be compared. If there are four criteria's say A, B, C, D then there will be six pairs i.e. A/B, A/C, A/D, B/C, B/D & C/D. similar, if there are also sub-criteria's they all are compared pairwise.

Following table8.1 is used to scale pairwise comparisons:

Preference weights/ level of importance	Definition	Explanation
1	Equally preferred	Two elements contribute equally to the objective
3	Moderately preferred	Experience and judgment slightly favour one element over another
5	Strongly preferred	Experience and judgment strongly or essentially favour one element over another
7	Very strongly preferred	An element is strongly favoured over another and its dominance demonstrated in practice
9	Extremely preferred	The evidence favouring one element over another is of the highest degree possible of affirmation
Intensities 2, 4, 6, and 8 can be used to express intermediate values. Intensities 1.1, 1.2. 1.3 etc. can be used for elements that are very close in importance.		

Table 8.1: Pairwise Comparisons

Once all the comparisons for Criteria and Sub criteria have been made, and we get the local priorities for each group at each level. One more step can be made here. We know how much the priority of each Criterion contributes to the priority of the Goal. Since we also know how much the priority of each Sub criterion contributes to the priority of its parent, we can calculate the *global priority* of each Sub criterion. That will show us the priority of each Sub

criterion with respect to the Goal. The global priorities throughout the hierarchy must be 1.000.

Comparing Alternatives

Alternatives are compared in the same way as criteria's and subcritria's were compared using the table (1)

6. MAKE THE DECISION

In the end, the AHP arranges and totals the global priorities for each of the alternatives. Their grand total must be 1.000, which is identical to the priority of the goal. Each alternative has a global priority corresponding to their criteria.

7. SELECTION PROCESS

7.1 ERP Selection Criteria

An ERP system is the information backbone of an organization Thus, long-term business strategy of the organization will form the basis of the selection criteria of an ERP system. The selection of the most appropriate solution is a semi-structured decision problem because only a part of it can be handled by a definite or accepted procedure such as standard investment calculations and on the other hand the decision maker needs to judge and evaluate all relevant business impact aspects.

The modules that an ERP offers, are the most important selection reasons; varying according to the needs of the organization. Following are the few of the criteria's need to be consider while selecting ERP system:

- *Customization:* Since different organizations need different software, they need to adapt the available software in the market for their own use. But, customizations shouldn't cause difficulties in updating to future software releases.
- *Implementability:* Different ERPs have different requirements, thus it is important to choose an implementable one.
- *Maintenance:* The software should support multi-company, multi-division and multi-currency environments. There shouldn't be any restrictions to this type of environment so that whenever an add-on procedure or a patch is available, it can be updated immediately.

- *Real Time Changes:* The modules should work in real time with online and batch-processing capabilities, so that no errors would occur because of the system being not up-to-date and information available to a department wouldn't be different than the other departments.

- *Flexibility:* Flexibility denotes the capability of the system to support the needs of the business over its lifetime. As the business requirements of the organization change, it should be able to add extra modules. The ERP should be flexible in order to suit the organizational culture and business strategy.

- *User Friendliness:* Most of the time, the end-users of an ERP system are not computer experts, thus their opinions about the software are highly valuable. The product shouldn't be too complex or sophisticated for an average user since the efficiency of end users directly affects the efficiency or the organization.

- *Cost:* Cost is an important issue since the implementing organization may be a small or medium sized enterprise (SME). ERPs are generally complex systems involving high cost, so the software should be among the edges of the foreseen budget.

- *Systems Requirements:* Technology determines the longetivity of the product. It is important to choose an ERP that is independent of hardware, operating system and database systems. The ERP system design should also not conflict with the organization's business strategy.

- *After Sales Support & Training:* The vendor should be providing the training as well as the after sales support, since ERPs are fairly complex applications for learning by oneself. Also it should be considered that every department within the organization would have its own piece of software to use, so a kind of specialized training will be needed for each department.

- *Back-up System:* To obtain the security for highly complex systems with huge databases, providing a very well-formed network is not enough; the back-up unit of the system should be more than reliable. Users should be able to schedule routine and partly back-ups. Besides, the back-up unit should also offer a solution for restoring the system within the shortest time.

- *Reporting & Analysis Features:* Besides standard reports, management team should be able to implement their own reporting and analysis tools.

- *Vendor Credentials:* Vendor's market share, reputation, number of consultants, number of installations performed, support infrastructure and demonstration of previous implementations are critical factors showing the commitment of the vendor to the product.

- *Integration with Other Software/Applications:* The modules should be integrated and provide seamless data flow among the other modules, increasing operational transparency. In case a third party application is needed, the ERP should be available to exchange data with the application, since data import/export is widely used techniques.

- *Internet Integration:* The software should support e-business, e-commerce and EDI transactions. At least, even if it doesn't have as built-in modules, Internet adaptation should be available as add-on modules.

7.2 Selection of ERP System - Example

Step 1: **An important part of the process is to accomplish these three steps:**
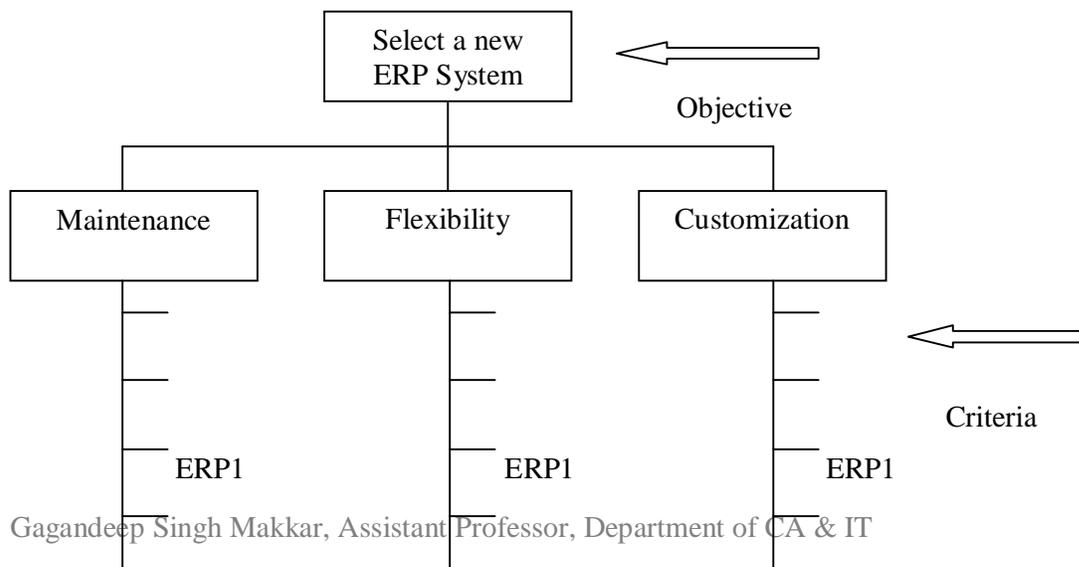**Objective:**
  – Select a new ERP system
Criteria:
  – Maintenance, Flexibility, Customization
Alternatives:
  – ERP1, ERP2, ERP3, ERP4

Step 2: **This Information Is Then Arranged In A Hierarchical Tree (figure 8.2):**

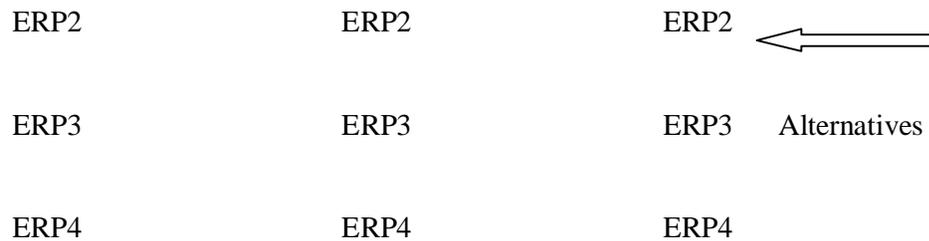|		
ERP2	ERP2	ERP2 ⟵
ERP3	ERP3	ERP3 Alternatives
ERP4	ERP4	ERP4

Figure 8.2: Hierarchical tree

The information is then synthesized to determine relative rankings of alternatives. Both qualitative and quantitative criteria can be compared using informed judgments to derive weights and priorities.

Step3: **Determine the Relative Importance Of The Criteria**

We have chosen three criteria's for selecting ERP among the four short-listed ERP. The three criteria are:

 i.   Maintenance
 ii. Flexibility
 iii. Customization

Let's suppose that management has taken decision that flexibility is the most important followed by maintenance and customization is least important to make the following judgments:

- Flexibility is 2 times as important as Maintenance
- Maintenance 3 times as important as Customization
- Flexibility is 4 times as important as Customization

Step4: **Pairwise Comparisons**

The relative importance of one criterion over another can be expressed using pairwise comparisons and is expressed in the form of pairwise matrix using the table 8.1 as shown in matrix (8.1)

	Maintenance	**Flexibility**	**Customization**
Maintenance	1/1	1/2	3/1
Flexibility	2/1	1/1	4/1
Customization	1/3	1/4	1/1

Matrix 8.1: The relative importance of one criterion over another using pairwise comparisons

Step 5: **Getting A Ranking Of Priorities From A Pairwise Matrix**

Dr Thomas L. Saaty demonstrated mathematically that the **Eigenvector** solution is the best approach for getting a ranking of priorities from a pairwise matrix. Following are the steps for solving the Eigenvector:

1. A short computational way to obtain this ranking is to raise the pairwise matrix to powers that are successively squared each time.

2. The row sums are then calculated and normalized.

3. The computer is instructed to stop when the difference between these sum's in two consecutive calculations is smaller than a prescribed value.

To get the Eigenvector, let's remove the names from matrix (8.1) and convert the fractions to decimals:

$$
\begin{pmatrix}
1.0000 & 0.5000 & 3.0000 \\
2.0000 & 1.0000 & 4.0000 \\
0.3333 & 0.2500 & 1.0000
\end{pmatrix}
$$

Step 5.1: **Squaring The Matrix (matrix 8.2)**

$$\begin{pmatrix} 1.0000 & 0.5000 & 3.0000 \\ 2.0000 & 1.0000 & 4.0000 \\ 0.3333 & 0.2500 & 1.0000 \end{pmatrix} * \begin{pmatrix} 1.0000 & 0.5000 & 3.0000 \\ 2.0000 & 1.0000 & 4.0000 \\ 0.3333 & 0.2500 & 1.0000 \end{pmatrix}$$

I.e. (1.0000 * 1.0000) + (0.5000 * 2.0000) +(3.0000 * 0.3333) = 3.0000

$$= \begin{pmatrix} 3.0000 & 1.7500 & 8.0000 \\ 5.3332 & 3.0000 & 14.0000 \\ 1.1666 & 0.6667 & 3.0000 \end{pmatrix}$$

Matrix 8.2: Square of Matrix 8.1

Step 5.2: **Let's compute our first Eigenvector (to four decimal places) as follows (from figure 8.2):**

i.   Sum the rows

ii.   Sum the row totals

iii. Normalize by dividing the row sum by the row totals

$$\begin{pmatrix} 3.0000 & + & 1.7500 & + & 8.0000 \end{pmatrix} = 12.7500$$

$$5.3332 \quad + \quad 3.0000 \quad + \quad 14.0000 \quad = 22.3332$$

$$1.1666 \quad + \quad 0.6667 \quad + \quad 3.0000 \quad = 4.8333$$

$$39.9165$$

To get the Eigenvector, divide the row sum by the row total, we get the following result: (i.e. 12.7500 divided by 39.9165 equals 0.3194). This result is normalized and the total sum of Eigenvector will be 1.0000 (matrix 8.3).

$$\begin{pmatrix} 0.3194 \\ 0.5595 \end{pmatrix}$$

$$0.1211$$

$$1.0000$$

Matrix 8.3: Eigenvector

Again Step 5.1: This process must be iterated until the eigenvector solution does not change from the previous iteration. Repeat the step 5.1 and square the matrix (8.2).

$$\begin{pmatrix} 3.0000 & 1.7500 & 8.0000 \\ 5.3332 & 3.0000 & 14.0000 \end{pmatrix} \times \begin{pmatrix} 3.0000 & 1.7500 & 8.0000 \\ 5.3332 & 3.0000 & 14.0000 \end{pmatrix}$$

$$1.1666 \quad 0.6667 \quad 3.0000 \qquad 1.1666 \quad 0.6667 \quad 3.0000$$

$$= \begin{pmatrix} 27.6653 & 15.8330 & 72.4984 \\ 48.3311 & 27.6662 & 126.6642 \\ 10.5547 & 6.0414 & 27.6653 \end{pmatrix}$$

Again step 5.2 : Compute the Eigenvector (to four decimal places)

$$\begin{pmatrix} 27.6653 & + & 15.8330 & + & 72.4984 \\ 48.3311 & + & 27.6662 & + & 126.6642 \\ 10.5547 & + & 6.0414 & + & 27.6653 \end{pmatrix} \begin{aligned} &= 115.9967 \\ &= 202.6615 \\ &= 44.2614 \\ &\overline{} \\ &362.9196 \end{aligned}$$

Divide the row sum by the row total to get new Eigenvector as given below:

$$\begin{pmatrix} 0.3196 \\ 0.5584 \\ 0.1220 \\ \overline{} \\ 1.0000 \end{pmatrix}$$

Compute the difference of the previous computed Eigenvector to this one:

$$\begin{pmatrix} 0.3194 \end{pmatrix} - \begin{pmatrix} 0.3196 \end{pmatrix} = -0.0002$$

|					
0.5595	—	0.5584	=		0.0011
0.1211	—	0.1220	=		− 0.0009

To four decimal places there's not much difference so there is no need of more iteration. Even if we make one more iteration, it will show no much difference to four decimal point.

Step 6: The computed Eigenvector gives us the relative ranking of our criteria.

Maintenance	0.3196		The second most important criteria
Flexibility	0.5584		The first most important criteria
Customization	0.1220		The third most important criteria

Step7: Putting the calculate weight (Eigenvector) to criteria define in the hierarchical tree as shown in figure (8.1), shown below

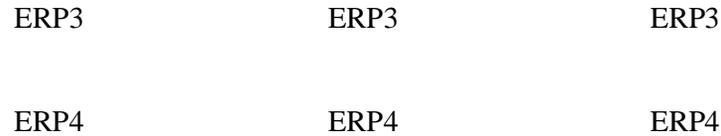| ERP3	ERP3	ERP3
ERP4	ERP4	ERP4
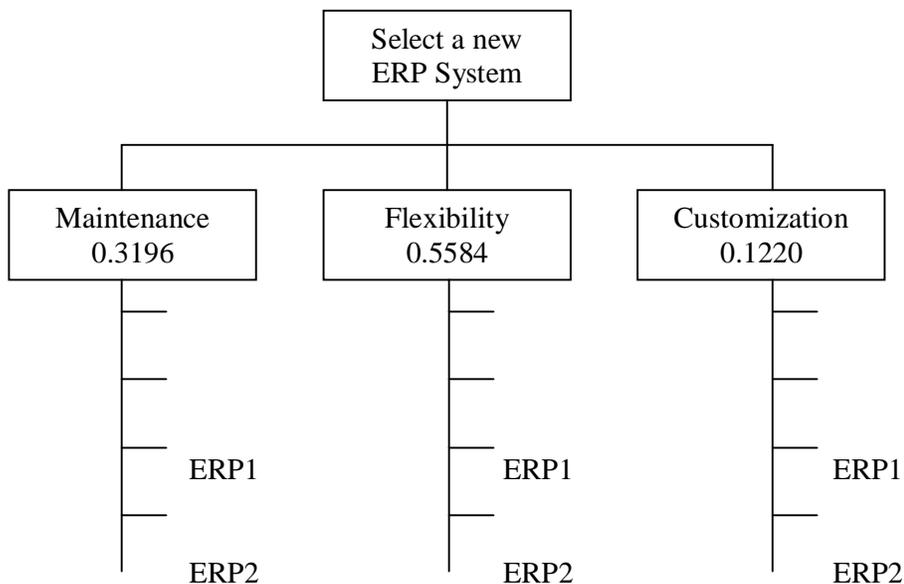
Figure (8.2): Hierarchical Tree with Criteria Weights

Step 8: **Pairwise Comparisons of alternatives**

In terms of Maintenance, pairwise comparisons determines the preference of each alternative over another (matrix 8.3)

Maintenance

	ERP1	ERP2	ERP3	ERP4
ERP1	1/1	1/4	4/1	1/6
ERP2	4/1	1/1	4/1	1/4
ERP3	1/4	1/4	1/1	1/5
ERP4	6/1	4/1	5/1	1/1

Matrix (8.3): Pairwise comparisons for ERP Maintenance

In terms of Flexibility, pairwise comparisons determines the preference of each alternative over another (matrix 8.4).

Flexibility

	ERP1	ERP2	ERP3	ERP4
ERP1	1/1	2/1	5/1	1/1
ERP2	1/2	1/1	3/1	2/1
ERP3	1/5	1/3	1/1	1/4

ERP4	1/1	1/2	4/1	1/1

Matrix (8.4): Pairwise comparisons for ERP Flexibility

In terms of Customization, pairwise comparisons determines the preference of each alternative over another (matrix 8.5).

Customization

	ERP1	ERP2	ERP3	ERP4
ERP1	1/1	1/4	3/1	1/4
ERP2	2/1	1/1	4/1	1/2
ERP3	1/3	1/4	1/1	6/1
ERP4	4/1	2/1	1/6	1/1

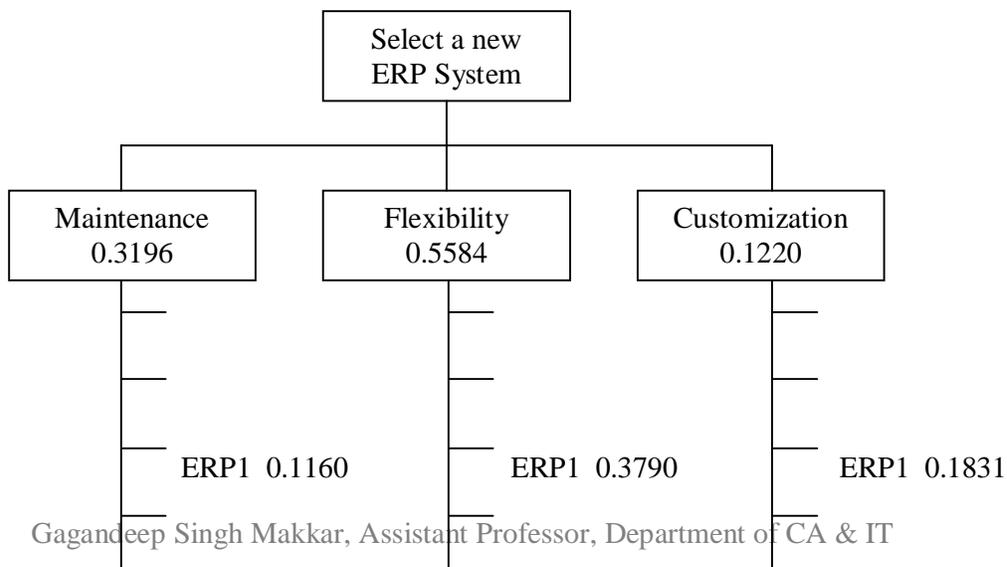*Matrix (8.5): Pairwise comparisons for ERP Customization*

Step 9: Computing the Eigenvector for each alternative that determines the relative ranking of alternatives under each criterion (matrices 8.6).

	Maintenance	Ranking		Flexibility	Ranking
ERP1	0.1160	3	ERP1	0.3790	1
ERP2	0.2470	2	ERP2	0.2900	2
ERP3	0.0600	4	ERP3	0.0740	4
ERP4	0.5770	1	ERP4	0.2570	3

	Customization	**Ranking**
ERP1	0.1831	4
ERP2	0.2822	2
ERP3	0.2995	1
ERP4	0.2352	3

Matrices 8.6: Eigenvector for Maintenance, Flexibility, and Customisation with ranking

Step10: Putting the calculated weight (Eigenvector) to alternatives define in the hierarchical tree as shown in figure (8.1) as shown in figure (8.3).

```
                    ┌─────────────┐
                    │ Select a new│
                    │ ERP System  │
                    └─────────────┘
         ┌─────────────────┼─────────────────┐
  ┌────────────┐    ┌────────────┐    ┌──────────────┐
  │ Maintenance│    │ Flexibility│    │ Customization│
  │   0.3196   │    │   0.5584   │    │    0.1220    │
  └────────────┘    └────────────┘    └──────────────┘
```

ERP1 0.1160   ERP1 0.3790   ERP1 0.1831

ERP2 0.2470	ERP2 0.2900	ERP2 0.2822
ERP3 0.0600	ERP3 0.0740	ERP3 0.2995
ERP4 0.5770	ERP4 0.2570	ERP4 0.2352

Figure (8.3): Hierarchical Tree with Eigenvector

Step 11: **Final Result**

To get the final result, multiply the criteria matrix with alternative matrix.

	Maintenance	**Flexibility**	**Customisation**		**Criteria Ranking**
ERP1	0.1160	0.3790	0.1831		0.3196
ERP2	0.2470	0.2900	0.2822	*	0.5584
ERP3	0.0600	0.0740	0.2995		
ERP4	0.5770	0.2570	0.2352		0.1220

i.e. For the ERP1 (0.1160 * 0.3196) + (0.3790 * 0.5584) + (0.1831 * .1220) = .2710

ERP1	0.2710
ERP2	0.2752
ERP3	0.0970

ERP4   0.3566

ERP4 has the highest rank, so company must go with ERP4 followed by ERP2 followed by ERP1 and ERP3has the lowest rank and is on the fourth position.

ERP4   0.3566

ERP2   0.2752

ERP1   0.2710

ERP3   0.0970

Step 12: **Benefit to cost ratio**

Cost of the ERP may also be one of the criteria for selecting the ERP for the company. Discussing costs together with benefits can sometimes bring forth many political and

Emotional responses. But In Complex decisions, costs should be set aside until the benefits of the alternatives are evaluated. There are many ways to handle benefits and cost, there are:

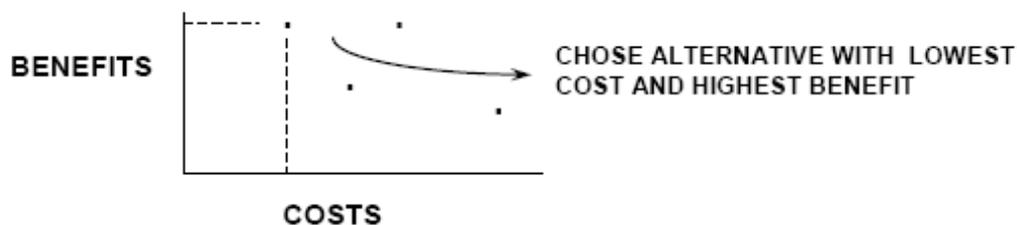i.   Graphing benefits and costs of each alternative (figure 8.4)

Figure 8.4: Benefits to costs ratio

ii.   Benefit to cost ratios

iii. Linear programming

iv.   Separate benefit and cost hierarchical trees and then combine the results

Let's use Benefit to Cost Ratio method to handle cost over benefits.

	Cost (In Lakh)	Normalized Cost	Benefit/Cost Ratio
ERP4	18	0.3333	0.3566/0.3333 = 1.0699
ERP2	12	0.2222	0.2752/0.2222 = 1.2385
ERP1	15	0.2778	0.2710/0.2778 = 0.9755
ERP3	09	0.1667	0.0970/0.1667 = 0.5819

The ERP2 has the highest benefit to cost ratio. So according to the benefit to cost ratio, ERP2 will be selected.

8.8 Merits of AHP

Following are the merits of the AHP:

1. AHP has the ability to mix qualitative and quantitative criteria in the same decision framework
2. AHP has the ability to integrate with techniques like goal programming
3. It is possible to incorporate risk factors in the AHP
4. It is very easy to incorporate sensitivity analysis in the AHP

8.9 Application of AHP

1. Choosing a new software package for the company
2. Choosing which employment offer to accept
3. Picking which computer or car etc. to buy
4. Selecting a sit for net hotel, restaurant etc.
5. Rating the best cities in which to live
6. Strategic planning
7. Resource allocation

8. Business policy