СДіТ

ПРОБЛЕМИ ПРИЙНЯТТЯ РІШЕНЬ І УПРАВЛІННЯ В ЕКОНОМІЧНИХ, ТЕХНІЧНИХ, ЕКОЛОГІЧНИХ І СОЦІАЛЬНИХ СИСТЕМАХ

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HOW TO MAKE AND JUSTIFY A DECISION: THE ANALYTIC HIERARCHY PROCESS (AHP)
PART 1. EXAMPLES AND APPLICATIONS

THOMAS L. SAATY

We describe and discuss a logical approach, the Analytic Hierarchy Process (AHP), that can be used to make decisions. It involves breaking the problem down into finer and finer parts so that one is called upon to give a judgment comparing only a pair of issues in each judgment.

1. INTRODUCTION

We describe and discuss a logical approach, the *Analytic Hierarchy Process (AHP)*, that can be used to make decisions. It involves breaking the problem down into finer and finer parts so that one is called upon to give a judgment comparing only a pair of issues in each judgment. This avoids mixing too many aspects of the problem and not knowing what goes with what to obtain the final answer. However, it does call for one to structure the problem hierarchically with broad understanding of the people and their interests and of the issues involved. Once one has the structure it becomes easier to convey to others the influences driving that decision.

The AHP has had appeal to managers and decision-makers at all levels of decision-making. It enables one to include both the strength of feelings needed to express judgment and the logic and understanding relating to the issues involved in the decision. It combines the multiplicity of judgments in a systematic way to obtain the best outcome, or mix of actions to be taken. Finally, and more significantly, these outcomes are derived in an agreeable way that are in harmony with our intuition and understanding and not forced on us by technical manipulations. There are easy to use software packages that implement this approach and make decision-making a pleasure. Expert Choice© is the name of one such software. For a free trial version go to www.expertchoice.com. We should be able to say that, given the information, we agree on the method of making the decision (if not the outcome of any particular decision). The matter becomes a common concern, not a mystical phenomenon.

The process contributes to solving complex problems by structuring a hierarchy of criteria, stakeholders, and outcomes and by eliciting judgments to develop priorities. It also leads to prediction of likely outcomes according to these judgments. The outcome can be used to rank alternatives, allocate resources, conduct

benefit/cost comparisons, exercise control in the system. by evaluating the sensitivity of the outcome to changes in judgment, and carry out planning of projected and desired futures. A useful by-product is the measurement of how well the leader understands the relations among factors. Although people generally are not consistent, the main concern here is the degree of their inconsistency. Is their understanding close to capturing the interactions observed? Or is it a random understanding that only hits the target now and then?

Good decisions must survive the difficulties and hazards of people and environment. We need to make decisions that are both desirable and survivable rather than simply ones that we best like without regard to how lasting they may be. Predicting outcomes plays an important role in making such choices. To do this well, we can decompose a decision into separate structures involving scenarios of benefits, costs, opportunities and risks and then carefully combine their separate outcomes for the best decision.

Decision–making groups need to formalize their agenda and structure the interaction. A process that can unfold the complexity of the issues or problems is much needed and would be particularly useful in group decision making. Recognizing that perceptions and stakes can vary among group members, such a process should also specify how individuals can bargain on specific differences. Finally, it would be desirable to have a measure of the consistency of judgments which individuals give and which the group settles on. The Analytic Hierarchy Process described in this paper is such a process.

2. EXAMPLE 1 — CHOOSING A HUSBAND

1. Oksana is an attractive twenty seven year old MBA graduate with three years business experience from a middle class family wants to choose a husband from one of three suitors. Her criteria are age, looks, intelligence and economic status. Her suitors are.

2. Taras, a rugged looking 30 year old engineer with a well paying job, interested in his career and in rainsing a family. He is hard nosed, no nonsense kind of person, gentle and loving.

3. Ivan, a 37 year old promising artist who is very romantic but whose career is still developing. His income from day to day is uncertain, but he is a sensitive imaginative genius with a lot of promise, but who is more interested in beauty and spirit than he is in accumulating wealth.

4. Grigoriy, a 25 year old handsome, virile and fast moving young man with a brilliant future in a famous and successful family business. He is extremely generous and thoughtful, but he is also temperamental and assertive in his ways.

The matrix of pairwise comparison judgments of the criteria given by the young lady in this case is shown in Table 1. The judgments are entered using the fundamental scale of the AHP: a criterion compared with itself is always assigned the value 1 so the main diagonal entries of the pairwise comparison matrix are all 1. The numbers 3, 5, 7, and 9 correspond to the verbal judgments «moderately more dominant», «strongly more dominant», «very strongly more dominant», and «extremely more dominant» (with 2, 4, 6, and 8 for compromise between the previous values). Reciprocal values are automatically entered in the transpose position, so she must make a total of $(4 \times 3)/2 = 6$ pairwise judgments. There

are 16 positions in all with four ones on the diagonal, half of the remaining 12 are the reciprocals of the others, so six judgments need to be entered. The priorities are obtained by raising the matrix to a large power to capture all the interactions, adding the entries in each row and dividing by the total sum of the rows. We are permitted to use decimal values between the integers, such as 2.6, if desired. It is mathematically demonstrated that it is necessary to use this scale to get meaningful results in practice. It represents the normal range of

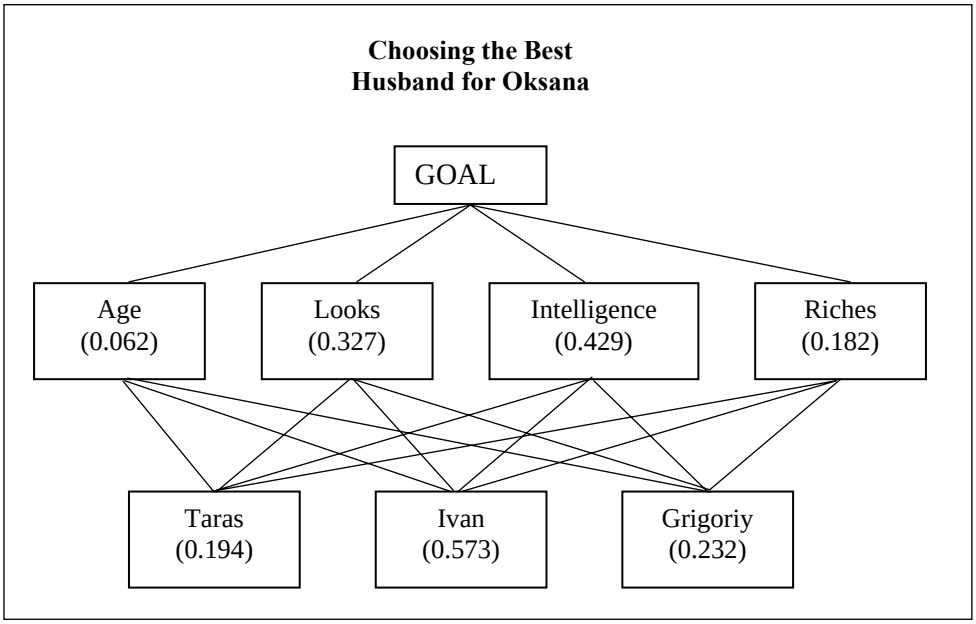

Fig. 1. The Best Husband Hierarchy

human sensitivity to phenomena that are homogeneous. When things are widely scattered, they can be grouped into separate clusters with a common element in adjacent clusters and the scale 1 to 9 is applied to compare the elements in each cluster with the common element serving as a link. When there are actual measurements for pairs being compared, such as money, we can use the ratio of their measurements.

It is generally preferable to use the verbal judgment and then enter the corresponding numerical value, although the software Expert Choice allows one to do either and in addition to use geometric representations of the relative strength of the paired comparison. In Table 1 below, when comparing Age on the left with Looks on Top, she thought that Looks are very strongly more important, and the value 1/7 is entered in the (Age, Looks) position, and automatically a 7 is entered in the (Looks, Age) position. Similarly, in comparing Intelligence with Looks, it is thought that Intelligence is slightly more important than Looks, and a 2 is entered in the (Intelligence,Looks) position, and a 1/2 is entered in the (Looks, Intelligence) position and so on. We always compare the criterion on the left as to how much more dominant it is than the criterion at the top. If it is not, the reciprocal value is used.

Table 1. Comparing the Criteria for Importance with Respect to the Goal

	Age	Looks	Intelligence	Riches	Priorities
Age	1	1/7	1/5	1/3	0.062
Looks	7	1	1/2	2	0.327
Intelligence	5	2	1	2	0.429
Riches	3	1/2	1/2	1	0.182

Inconsistency Value 4%

Table 2. Comparing the Suitors with Respect to the Criteria

Age	Taras	Ivan	Gritsko	Priorities
Taras	1	3	1/3	0.258
Ivan	1/3	1	5	0.105
Gritsko	3	1/5	1	0.637

Inconsistency Value 4%

Looks	Taras	Ivan	Grigoriy	Priorities
Taras	1	1/5	2	0.166
Ivan	5	1	7	0.740
Gritsko	1/2	1/7	1	0.094

Inconsistency Value 1%

Intelligence	Taras	Ivan	Grigoriy	Priorities
Taras	1	1/5	3	0.188
Ivan	5	1	7	0.731
Grigoriy	1/3	1/7	1	0.081

Inconsistency Value 6%

Riches	Taras	Ivan	Grigoriy	Priorities
Taras	1	5	1/4	0.237
Ivan	1/5	1	1/8	0.064
Grigoriy	4	8	1	0.699

Inconsistency Value 9%

In Table 3 we multiply the weights of the suitors by the weights of the criteria and add to obtain the final ranking.

Table 3. Synthesis of the Priorities

Criteria / Suitors	Age (0.062)	Looks (0.327)	Intelligence (0.429)	Riches (0.182)	Priorities Synthesis
Taras	0.258	0.166	0.188	0.237	0.195
Ivan	0.105	0.740	0.731	0.064	0.573
Gritsko	0.0637	0.094	0.081	0.699	0.232

Ivan wins because he has better looks and is more intelligent. Both criteria have high priorities of 0.327 and 0.429 or a total of 0.756 of the assessment. Thus, she should marry Ivan the artist.

3. EXAMPLE 2 — SELECTING A PIPELINE ROUTE IN SOUTH AMERICA

Executives of a South American oil company must choose among three locations for construction of an oil pipeline. The alternatives are a northern route to Covenas, a southern route to Orito, and a western route to Bahia. The southern and western routes terminate on the west side of the Panama canal and the northern route terminates on the east side; selecting the western route would result in a $1 per barrel increase in profit due to transportation savings. While this is a factor affecting NPV(Net Present Value), management has to balance its profit motives with concerns for the environment, managerial control, and the riskiness of the venture. So, in the end the cost savings due to transportation are not sufficient to make the western route the best.

During the decision session discussion among vice presidents, engineers, and operating managers of the company was instructive as each group member learned from the others' information and insights.

The problem of choosing the best route for the pipeline is shown in Figure 2. Notice that some criteria have subcriteria – for example, risk is broken down into vulnerability, reliability, and design considerations. The alternatives are evaluated directly for the criterion Net Present Value, but for the subcriteria under Risk. ECP refers to equal capital partners. The reader will have no difficulty in understanding the factors represented here.

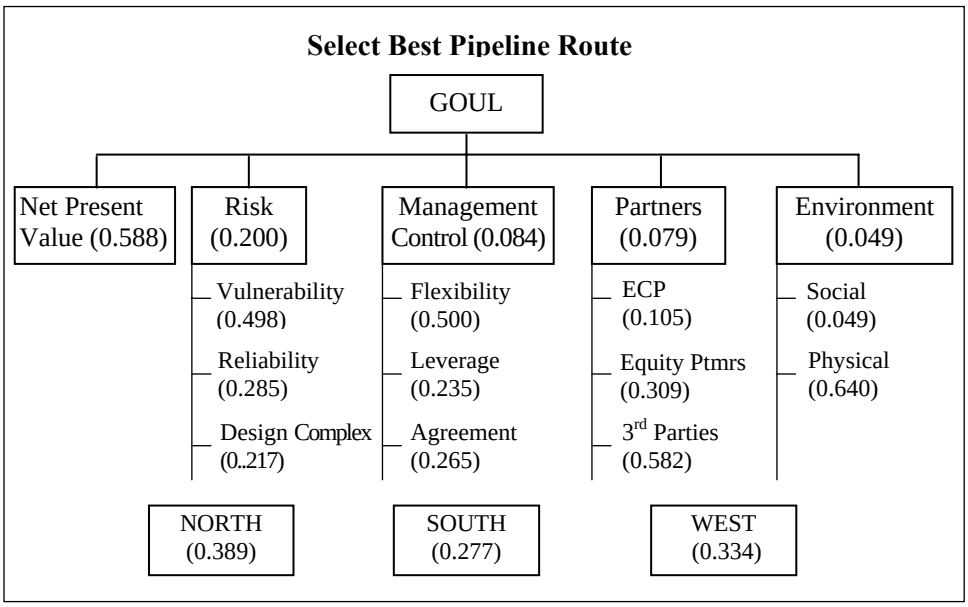

Fig. 2. The Pioeline Decision Model

The next step is to make comparative judgments. The decision-making group from the oil company assessed the relative importance of all possible pairs of criteria with respect to the overall goal *Select Best Pipeline Route*, coming to a consensus judgment on each pair. Their judgments are arranged into a matrix. The process has a scientific way of combining individual judgments that we will not go into here. The question to ask when comparing two criteria is: which is more important and how much more important is it with

respect to selecting the best pipeline route? First the criteria are compared for their importance with respect to the goal as shown in below:

Table 4. Comparing the Criteria for Importance with Respect to the Goal

	Net Present Value (NPV)	Risk	Management Control	Partners	Environment	Priorities
NPV	1	6	7	7	6	0.588
Risk	1/6	1	3	5	3	0.200
Mgt. Control	1/7	1/3	1	1	3	0.084
Partners	1/7	1/5	1	1	3	0.079
Environment	1/6	1/3	1/3	1/3	1	0.049

Inconsistency Value 11%

Then the subcriteria are compared with respect to their importance to the criterion they fall beneath. For an example of comparing the subcriteria beneath the criterion Partners, see Table 5. Finally the alternatives are compared with respect to each of the criteria or subcriteria above them as in Table 6.

Table 5. Judgments under Criterion Partners.

Partners	ECP	Equity	3rd Party	Priorities
ECP	1	1/3	1/2	0.163
Equity	3	1	2	0.540
3rd Parties	2	1/2	1	0.297

Inconsistency Value 0%

Table 6. Judgments for Alternatives under Subcriterion Physical.

Physical	North	South	West	Priorities
North	1	1/3	1/2	0.163
South	3	1	2	0.540
West	2	1/2	1	0.297

Inconsistency Value 1%

The priorities for each set of judgments, as shown in Table 7 are combined by multiplying the values for North, South and West under each criterion or subcriterion directly linked to the routes, by the weighted value shown for the criterion or subcriterion and adding. The priorities of the criteria and subcriteria (called covering criteria of the alternatives) sum to 1.000. The best overall choice is seen to be the Northern route. Fig. 3 is a bar representation of the outcome.

Fig. 3. The final results

Table 7. Synthesis for Final Answer

	NPV 0.588	Vulnr 0.099	Reliab 0.057	Design 0.043	Flexibl 0.042	Lever 0.020	Agree 0.022	...
North	0.312	0.605	0.630	0.659	0.726	0.182	0.182	
South	0.304	0.210	0.151	0.540	0.172	0.273	0.273	
West	0.384	0.184	0.218	0.297	0.102	0.545	0.545	

...	ECP 0.009	Equity 0.024	3rd Pty 0.046	Social 0.018	Phys 0.031	Overall Priority
	0.122	0.094	0.669	0.190	0.163	0.389
	0.230	0.167	0.243	0.547	0.540	0.277
	0.648	0.740	0.088	0.263	0.297	0.334

The sensitivity graph shown in 4 allows analysis of the result. The graph shows how each route performs on each criterion. The importance of the criteria themselves is represented by the vertical bars. For example, Risk is about 20% of the concern, while NPV is almost 60%. The line for the North alternative intersects the Risk axis the highest up, so it is best on Risk. But it is worst on the environment, and so on, but overall, the Northern route just edges out the Western route and is the best.

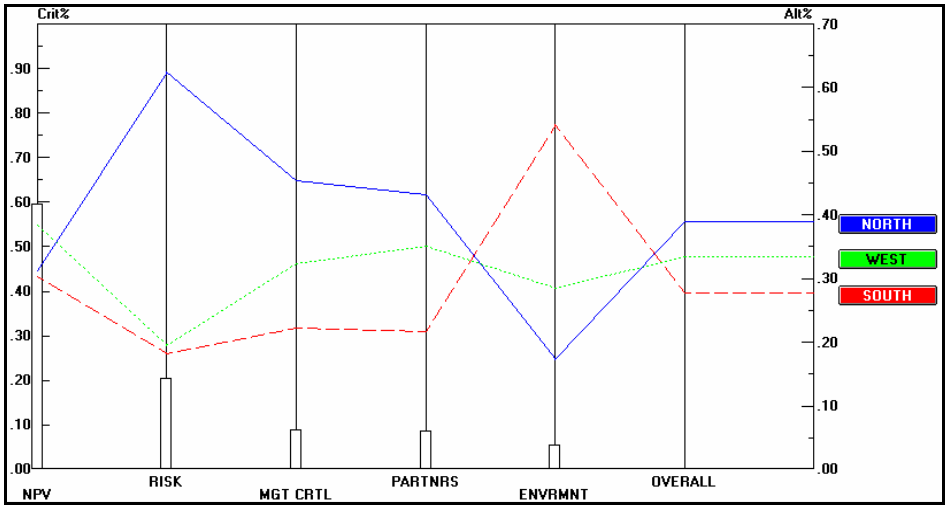

Fig. 4. Sensitivity Graph showing Performance of Alternatives on Criteria

4. ABSOLUTE MEASUREMENT

Another method of ranking alternatives to evaluate them one at a time rather than compare them in pairs. This is particularly useful when their number is large and there is expert knowledge about standards they must satisfy. This process involves introducing and prioritizing intensities for each of the criteria or subcriteria above the alternatives. For example, the criterion Net Present Value

may take on the intensities, Very High, High, Medium, Low and Very Low. One pairwise compares these intensities as to how preferred they are to each other just as we did in the comparison matrices above, and thus obtain priorities for them. After doing this, one assigns one intensity from each criterion for each alternative, weights it by the importance of its criterion and adds to obtain the overall priority for that alternative. This process also lends itself well to resource allocation as shown in the following example of allocating raise money to employees.

Evaluating Employees for Raises. Employees are evaluated for raises. The criteria are Dependability, Education, Experience, and Quality. Each criterion is subdivided into intensities, standards, or discrimination categories as shown in Figure 5. Priorities are set for the criteria by comparing them in pairs. The intensities are then pairwise compared according to importance with respect to their parent criterion (example as in Table 8). Their priorities are often divided by the largest intensity for each criterion (second column of priorities in Fig. 5) particularly useful in preserving the ranks of the alternatives from the addition or deletion of other alternatives. Finally, each individual is rated in Table 9 by assigning the intensity rating that applies to him or her under each criterion and adding. The score of each assigned intensity is weighted by the priority of its criterion and summed over the criteria to derive a total ratio scale score for each individual. This approach can be used whenever it is possible to set priorities for intensities of the criteria, which is usually possible when sufficient experience with a given operation has been accumulated.

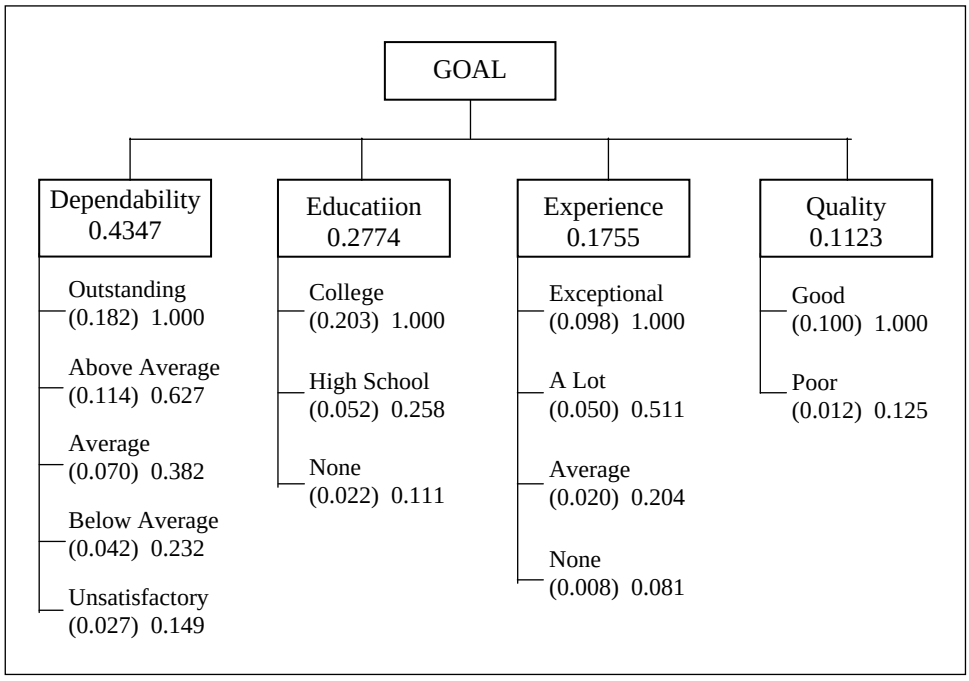

Fig. 5. Employee evaluation hierarchy

Table 8. Ranking Intensities

	Outstanding	Above Average	Average	Below Average	Unsatisfactory	Priorities
Outstanding	1.0	2.0	3.0	4.0	5.0	0.419
Above Average	1/2	1.0	2.0	3.0	4.0	0.263
Average	1/3	1/2	1.0	2.0	3.0	0.160
Below Average	1/4	1/3	1/2	1.0	2.0	0.097
Unsatisfactory	1/5	1/4	1/3	1.2	1.0	0.062

Inconsistency Ratio = 0.015

Table 9. Ranking Alternatives

	Dependability	Education	Experience	Quality	Total	Normalized
1. Adams, V	Outstanding	College	Exceptional	Good	1.000	0.245
2. Becker, L	Average	College	Average	Good	0.592	0.145
3. Hayat, F	Average	College	A lot	Good	0.645	0.158
4. Kesselman,S	Above Average	High School	None	Poor	0.373	0.091
5. O'Shea, K	Average	College	Average	Poor	0.493	0.121
6. Peters, T	Average	College	None	Good	0.570	0.140
7. Tobias, K	Above Average	None	A Lot	Poor	0.470	0.100

The raises can be made in proportion to the normalized values on the right.

5. OTHER APPLICATIONS

Organ Transplantation. The City of Pittsburgh was for a while a leader in the world in organ transplantations. Because there are more patients who need livers, hearts and kidneys than there are available organs, it had become essential to assign priorities to the patients. The goal is divided into: emotionally dependent and financially dependent patients: Both are divided into single, married, and divorced with and without dependent and financially dependent patients. Then each of them is further divided into: medical history (time on donor list, degree of disability), physical history (degree of ability to endure rehabilitation, willingness to cooperate, etc.), and social status (criminal record, volunteer work). A patient is ranked according to the intensities under each criterion. The higher the total score the better the opportunity to receive a transplant. The covering criteria and subcriteria of the alternatives are each assigned intensities for which priorities are developed as in the salary raise example. In general, one would use the intensities to score a patient. When there is no intensity, either the full value of the criterion is assigned, or a zero value otherwise. For example, a person with no criminal record was assigned the full priority of the Criminal Record criterion which was in this case 0.033. A patient with a criminal record would receive a zero for that criterion.

Here are details of other examples of complex decisions that have been made using the AHP.

Vehicle Fleet Management. Vehicle fleet management policies and programs are tools by which the fleet manager meets the business/transportation requirements of organization personnel. These policies may be formulated by committees, management, or by the fleet manager. The model below provides fleet managers with a framework to select and establish the best policies according to their organizational objectives. Important objectives of fleet managers, who operate on a fixed budget, include minimizing cost, improving relationships with internal constituencies (purchasing, sales, marketing, accounting, vehicle maintenance, and finance departments), improving relationships with external constituencies (leasing companies, auto manufacturers, auto dealers, contract mechanics, parts vendors, and insurance companies), improving quality of the fleet, and improving safety, maintenance, and scheduling aspects of fleet management. This particular decision examines two alternative policies: fleet downsizing (smaller vehicle size), and decreasing the number of vehicles in the fleet. Not implementing a new policy, nor maintaining the status quo, could also be considered as an alternative.

Product Marketing Strategy. The traditional focus of product management has been on the introduction of new products. However, in recent years, there has been increasing concern on the part of organizations about product lines that are fast approaching obsolescence or are slow–moving. While companies have formalized evaluation programs to monitor and assess the performance of their product offerings, the decision-making process for product modification and/or elimination strategies remains unstructured. This decision determines a future marketing strategy for a product identified as a problem or for late–to–mature products. The decision to delete the product, modify the product marketing strategy, or maintain the status quo is examined in light of the desired corporate image, market share, competition, synergies of manufacturing, marketing, distribution, end uses, investment requirements for R&D and equipment, human resource requirements, manufacturing resource requirements, financial considerations, preferences of customers, suppliers and distributors, and the corporate legal, political, and economic environment. Slight modifications to the decision add the capability to assess whether or not proposed additions should be made to the product line.

Bank Acquisition. The New National Bank (NNB) has conducted an analysis to uncover and identify its basic motive for expansion. One motive for expansion is sales enhancement through product extension; a second motive for expansion is cost reduction through economies of scale or improved operating efficiency which eliminates excess capacity and overhead expenses. NNB realizes that acquisitions can be a powerful tool in adapting to deregulation, excess capacity, and thinning margins. However, achieving value–added growth through acquisition can be difficult for bank acquisition because prices frequently exceed twice the book value. After determining that expansion was desirable, and acquisition was preferable to internal development, NNB narrowed down its choice to two possible candidates which would best fit its acquisition strategy: Bank A and Bank B.

BANK A is headquartered in Pittsburgh, Pennsylvania, and is the nation's thirteenth largest bank holding company with assets of $3 billion. The building it

resides in and owns is considered to be a historical landmark. BANK B is headquartered in Wilmington, Delaware and has assets of $1.5 billion. Its credit card operation is one of the largest in the nation. In addition, Delaware state law has no ceiling on credit card interest rates and has lower income tax rates. NNB has developed a comprehensive framework for evaluation that combines strategic, financial, operating, and integrating factors. The final determination of the ideal candidate depends on a comparison of the benefit/cost advantages of each. The costs used in this comparison are compatibility, personnel, interest rate ceiling on credit cards, and taxes. The benefits include financial value, geographic expansion, product expansion, and reputation.

Mergers and Acquisitions. When studying motivations for mergers and acquisitions, analysts run up against a lack of reliable evidence with which to conclusively support motivation theory; the majority of mergers do not actually seem to be profitable for the acquiring firm's stockholders. To better determine the future success of proposed mergers, judgments may be entered for a specific merger prospect for an acquisition firm into the model below by two different decision makers, The first decision maker holds the neoclassical view that mergers occur because managers want to maximize shareholders wealth. Managers are more interested in retaining their jobs in the merged firm than they are in personal profit or post–merger stock price. The second decision maker believes managers wish to maximize their own wealth and satisfy a psychological need for growth and power. While managers are concerned about the merged firm's eventual profit and stock price, this concern stems from a desire to maximize their personal profits. It is interesting to note that although the decision-makers assume different motives for the mangers, there were no significant differences in their predictions of successful mergers. The criteria the decision-makers use include target company's stockholders and managers, the Federal Trade Commission, and the Justice Department. The alternatives are no attempt at a merger, a failed merger, and a successful merger.

Choosing a Telecommunications System. The success or failure of many businesses today depends a great deal on the ability of a business to communicate with its customers, with other offices, and with suppliers. This model is built to assist a small to medium size health care company, Megadata, choose a telecommunications system. Megadata provides doctors, hospitals, and other health care providers with easy and efficient transfers of medical insurance information and diagnoses. Rapid transfer of this information allows doctors and hospitals to minimize their operating expenses and make better decisions by sharing information between experts across the country. Megadata depends on its ability to transfer large amounts of data via the national telephone network. The company is considering buying a new Private Branch Exchange (PBX) to minimize long–term costs, increase flexibility to expand as the company expands, minimize down–time due to maintenance, provide ease of use for end-users and network administrators, and include several key options to improve operations. Megadata's alternatives are: to ignore the increasing demand for telephonic transfer of data and continue operating with the current system (it is estimated that the system will operate for another two to three years without serious impact on income), to buy a «top of the line» system that will provide the company with the advantages of many new technological breakthroughs, or to purchase a

refurbished older, but fairly reliable system, that can provide adequate service for another six to ten years.

Government/Public Strategy: Should Dam Construction occur on Alaska's Susitna River? No other single man–made endeavor has ever changed the face of the earth to the same extent as have dams. In addition to the alteration of the land's geography, far-reaching implications of dams encompass political, social, ecological, economic, and psychological aspects. While dam construction benefits man through flood control, provision of electrical power and water resources, irrigation, and recreational facilities, the detriments are often more opaque and not so easily quantified. Dam construction causes displacement of citizens, and there has been greater incidence of disease accompanying dam construction historically. While some marine species may be cultivated by existing dam reservoirs, other species face potential extermination. Dams also tend to affect other ecosystems in the surrounding area, and cause erosion of surrounding terrain. Additionally, there exists a safety hazard from the dam as it advances in age. This model determines whether to build a proposed dam on Alaska's Susitna River. The Susitna, with a drainage area of more than CAPut!',000 square miles is the sixth largest river in Alaska and is an important, productive, fishery resource which contributes to the support of significant wildlife populations in the virtually untouched and relatively inaccessible lands across which it flows. Various development schemes to harness the extensive hydro-electric potential of the Susitna have been advanced by public agencies and private organizations. This model was used to evaluate whether or not to build a proposed dam given short and long term environmental effects, safety factors, power generated, employment created, and other financial, economic, and political considerations.

Here are some other recent decisions that have been made using the AHP:

- British Airways used it in the late 1990's to decide on the vendor to use for the entertainment system on its entire fleet of airplanes in the new century.
- An oil company used it in the late 1980's to determine the best type of platform to build for drilling for oil in the North Atlantic. A platform costs around 3 billion dollars to build, but the demolition cost was an even more significant factor in the decision.
- The process was applied to the U.S. versus China conflict in the intellectual property rights battle of 1995 over Chinese individuals copying music, video and software tapes and CD's. An AHP analysis involving three hierarchies for benefits, costs and risks showed that it was much better for the U.S. to not sanction China. Shortly after the study was complete, the U.S. awarded China most-favored nation trading status and did not sanction it.
- Xerox Corporation has used the AHP to allocate close to a billion dollars to its research projects.
- The Ford Motor Company, in 1999, used the process to establish priorities for criteria that improve customer satisfaction. Ford gave Expert Choice Inc, the software company which helped them with the study, an Award for Excellence for helping them achieve greater success with their clients.
- In 1986 the Institute of Strategic Studies in Pretoria, a government-backed organization, used the process to analyze the conflict in South Africa and recommended actions ranging from the release of Nelson Mandela to the removal

of apartheid and the granting of full citizenship and equal rights to the black majority. All of these recommended actions were implemented within a relatively short time.

- The AHP has been used in student admissions, military personnel promotions and hiring decisions.
- In sports it was used in 1995 to predict which football team would go to the Superbowl and win (correct outcome, Dallas won over my hometown, Pittsburgh), and the process was applied in baseball to analyze which Padres players should be retained. Such applications take several days to make, to capture sufficient knowledge and detail.
- IBM used the process in 1991 in designing its successful mid-range AS 400 computer. IBM won the prestigious Malcolm Baldrige award for excellence for that effort. A book, the Silverlake Project (Bauer, 1992), was written about the AS 400 project and has a chapter devoted to how AHP was used in benchmarking.

Since the AHP helps one organize one's thinking, it can be used tos deal with many decisions that are often made intuitively. As a minimum the process allows one to experiment with different criteria and different judgments. A trial version of the AHP software can be obtained from www.expertchoice.com.

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