POLICY SPECIFYING WITH APPLICATION TO PERSONNEL CLASSIFICATION AND ASSIGNMENT

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INTRODUCTION

Personnel of the Air Force Human Resources Laboratory have been developing and applying procedures for creating models of judgment processes for over twenty years. The initial efforts were concerned with representing the judgments of Air Force personnel classification specialists. Out of these efforts have grown many insights into Judgment Modeling, as well as new ways to look at this problem. This paper discusses the latest development at AFHRL in Judgment Modeling and details the evolution of a new technique known as Hierarchical Policy Specifying. An example of how this technique has been used in personnel classification and assignment will be presented.

OBJECTIVE AND EXAMPLES

The objective of Judgment Modeling is to combine several different types of information into a single indicator of "value," "payoff," or "utility." A significant operational example of this is the Air Force Weighted Airman Promotion System (WAPS) which is used for promotion to grades E-4 through E-7. The objective of this project was to determine how to combine several different types of personal information, such as time in grade, specialty knowledge, awards and decorations, and performance ratings, into a single index of promotability. In this case, a technique known as judgment analysis (or policy capturing) was used to develop the weighting equation. Another example within the Air Force was the need to combine information about people and jobs to reflect the "payoff" to the Air Force of assigning a particular person to a particular job at a particular time. This was accomplished using a technique known as policy specifying within the Air Force Person Job Match (PJM) system. Other examples of the need to combine multiple information into a single value are: graduate admissions policy, performance appraisal, financial analysis, research and development resource allocation, officer grade requirements, job difficulties, and national recovery policy.

JUDGMENT MODEL DEVELOPMENT

The Air Force has developed some methodologies for dealing with these types of situations using systematic approaches. The procedures that will be presented in this paper are not meant to exhaust the list of ways to deal with procedures for combining multiple items of information to produce a single representation of the payoff judgments of one or more individuals. Some other methods are listed in the bibliography which include scaling methods (Saaty, 1977), behavioral decision theory (Slovic, Fischhoff, and Lichtenstein, 1977)

and utility theory (Keeney, and Raiffa, 1976). Three methods that will be examined in this paper and have been used in the Air Force are:

THREE METHODS

- POINT ALLOCATION
- JUDGMENT ANALYSIS or POLICY CAPTURING
- POLICY SPECIFYING

POINT ALLOCATION

The first method will be called point allocation. This method requires the identification of the relevant variables to be weighted and the desired payoff range. The expert consulted for the procedure allocates various percentages of points to each variable to be combined to yield the total payoff.

POINT ALLOCATION

TOTAL PAY-OFF RANGE = 100

Percent Pay-Off Allocated to X1 = 20

Percent Pay-Off Allocated to X2 = 30

Percent Pay-Off Allocated to X3 = 50

Can yield an explicit equation

$$Y = W_1 X_1 + W_2 X_2 + W_3 X_3$$

Given the percentage allocation points, an explicit equation could be defined, but in practice, the values of the W's and X's are not usually determined.

JUDGMENT ANALYSIS

The term judgment analysis will be used in this paper to describe the situation where judges are given decision situations and then their judgments are analyzed. The following steps are used in the judgment analysis procedure:

JUDGMENT ANALYSIS

Step 1. Identify the concept of interest (Y) and the variables (X's) which will be used to describe Y.

Step 2. Select one or more judges and a sample of decision situations to be judged.

Step 3. Judges assign values of Y to each decision situation.

Step 4. Obtain least squares regression to predict judgments in the form

$$Y = w_1 X_1 + w_2 X_2 + \ldots + w_p X_p + E$$

An example of how judgment analysis is used will be presented, using as the judge a young airman entering the Air Force for his first assignment. The judgment situation will be various assignment locations within the Air Force that the airman must rate. The example will consist of the following three variables:

JUDGMENT ANALYSIS EXAMPLE

Preference for Assignment Location (Y)

Function of:

- Cost of Living (X1)
- Population of Community (X2)
- Annual Snowfall (X3)

The airman is presented 150 samples of Air Force Base locations. These locations are not described in terms of name or location, but in the following terms:

PRESENT JUDGMENT SITUATIONS

Sample of 150 Air Force Base locations described in terms of

	Range
• Relative Cost of Living (X1)	1 (low)-7 (high)
• Population of Community in Thousands (X2)	0 - 1,000
• Annual Snowfall in Inches (X3)	0 - 100

Judgments are then obtained from the judge for each of the samples. He expresses his preference for each location using values from -9 (low) to +9 (high). For purposes of this example, the airman will be assumed to be a single, 19-year-old male from rural Minnesota. From the expressed preference values, the least squares weights are computed and a regression equation formed to predict his preferences. An example might be:

COMPUTE LEAST SQUARES

WEIGHTS TO PREDICT PREFERENCES

$$Y = W_0 + W_1 X_1 + W_2 X_2 + W_3 X_3 + E$$

$$Y = (-.91) + (-.00003) X_1 + (-.0002) X_2 + (.18) X_3 + E$$

This equation could be interpreted to show that the airman was most concerned with variable X_3, annual snowfall, since he was from Minnesota. The airman was least concerned about cost of living in this example since he was single. This equation could be used to predict the airman's preference for another location that he had not previously judged.

HIERARCHICAL POLICY SPECIFYING

The term Hierarchical Policy Specifying will be used in this paper to describe a decision theory methodology developed within AFHRL. This technique consists of the following steps:

POLICY SPECIFYING

Step 1. Identify the fuzzy concept of interest (Y) and the variables (X's) which will be used to describe Y.

Step 2. Select one or more Experts who will specify policy in mathematical form.

Step 3. Define a pair-wise hierarchy of the X's.

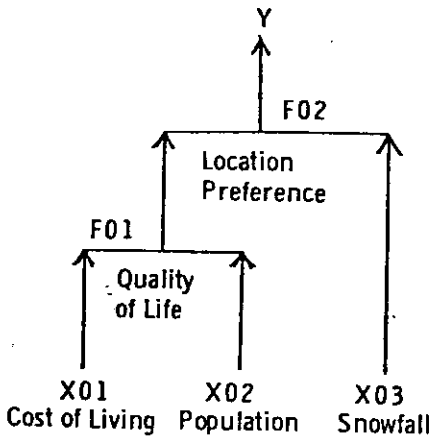
Step 4. Specify the pair-wise models.

The first step is similar to the first step of judgment analysis, except that often the concept of interest (Y) is fuzzy, i.e., there exists no device with which to measure the payoff or value of the alternatives available to the judge. Examples of this are the values to the Air Force of promoting an individual, and of classifying an individual in a certain job. Step 3 is probably the most important step and possibly the most difficult step in

the policy specifying procedure. The judge must interface with the modeler to define a hierarchy for the variables (X's) which will be used to specify the policy. An example of the pair-wise policy is constructed for the previous example of the preference for assignment location.

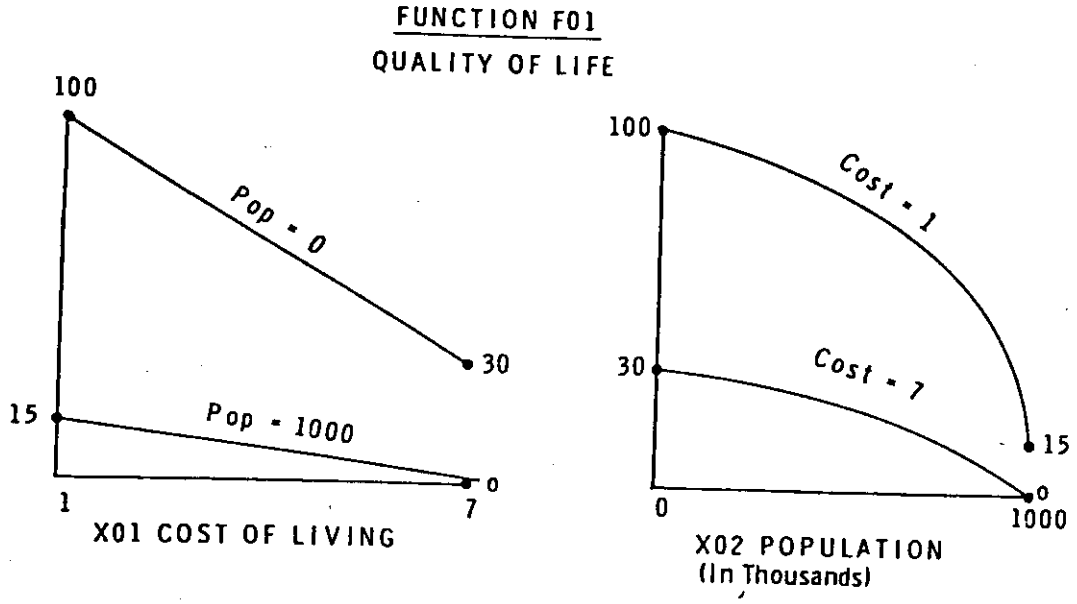
POLICY SPECIFYING EXAMPLE

PAIR-WISE HIERARCHY

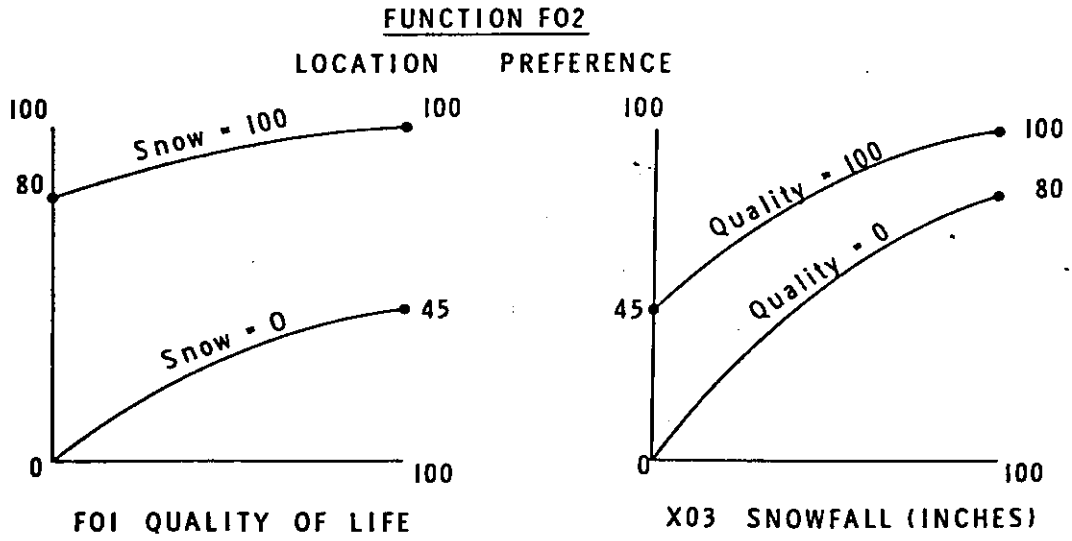


In this example, the judge and the policy modelers have decided that the variables X01 and X02 should be combined first using function F01. The output of this function will be called Quality of Life. Then the output of function F01 will be combined in the hierarchy with Snowfall (X03) using function F02 to give Y (Location Preference). As can be seen from the example, the order of combination in the hierarchy is somewhat arbitrary and different results might occur with a different order in the hierarchy. This is a research question which must be pursued in the future before too much can be said about the stability of a policy specified in this way.

Given the hierarchy, the modeler must then elicit from the judge responses which will allow him to construct functions F01 and F02. The expert is asked to describe how he feels about Cost of Living and Population. He specifies his preferences at the four extreme combinations of the two variables. In this example, the four values specified are 100, 30, 15, and 0. Then the judge specifies how the function output varies for each of the variables. In this case, he indicates that for different values of Cost of Living, the function output change is constant. This indicates the linear relationship shown. However, for the Population variable, he indicates that he is relatively indifferent for low values of Population, but as the population becomes large, the change in function output is much greater. This indicates the second order non-linear function shown.



The judge then proceeds to describe function F02, relating the output of F01 to Snowfall. For this function, the judge specifies the four extreme values as 100, 80, 45, and 0. He then specifies that for different values of Quality of Life, the function output varies as a non-linear curve of second degree. However, for Snowfall, he specifies that for low values of Snowfall any changes in Snowfall make a big difference, but for high values, he is relatively indifferent. The model maker translates this specification into a third order relation since the distinction between low and high values of Snowfall seems stronger than for Quality of Life.



The equation generated from the policy capturing procedure and the expanded version of the final policy specified equation (which is usually not explicitly developed) are as follows:

COMPARISON OF MODELS

Judgment Analysis

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + E$$

Policy Specifying

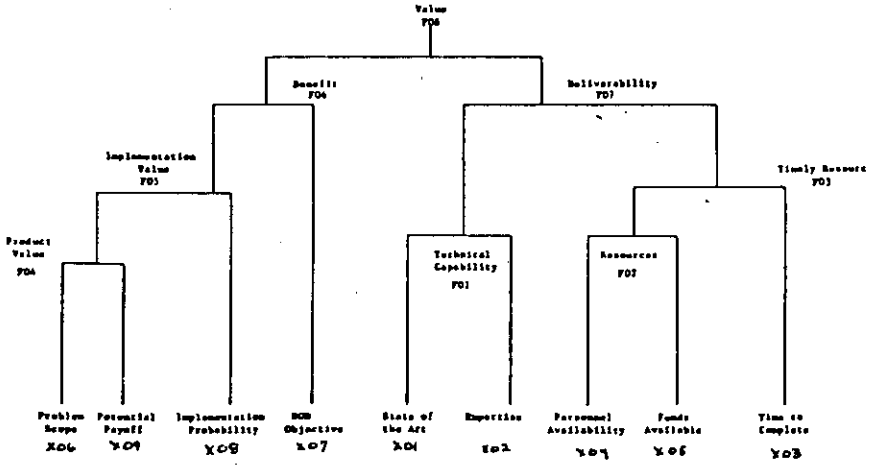
$$Y = a_0 + a_1 X_1 + a_2 X_2^2 + a_3 X_3 + a_4 X_1^2 + a_5 X_1 X_2^2$$

$$+ \ . \ . \ . \ +$$

$$a_{33} X_1^2 X_2^4 X_3^3 + a_{34} X_2^2 X_3^3 + a_{35} X_2^4 X_3^3$$

The judgment analysis model generally contains no product terms (interaction) and no higher order terms. Note also that the judgment analysis model contains an error term that can be used to determine accuracy of predicting the judgments. Policy specifying has been used for other applications within AFHRL. This is an example of a hierarchy specified for research evaluation and investment decisions.

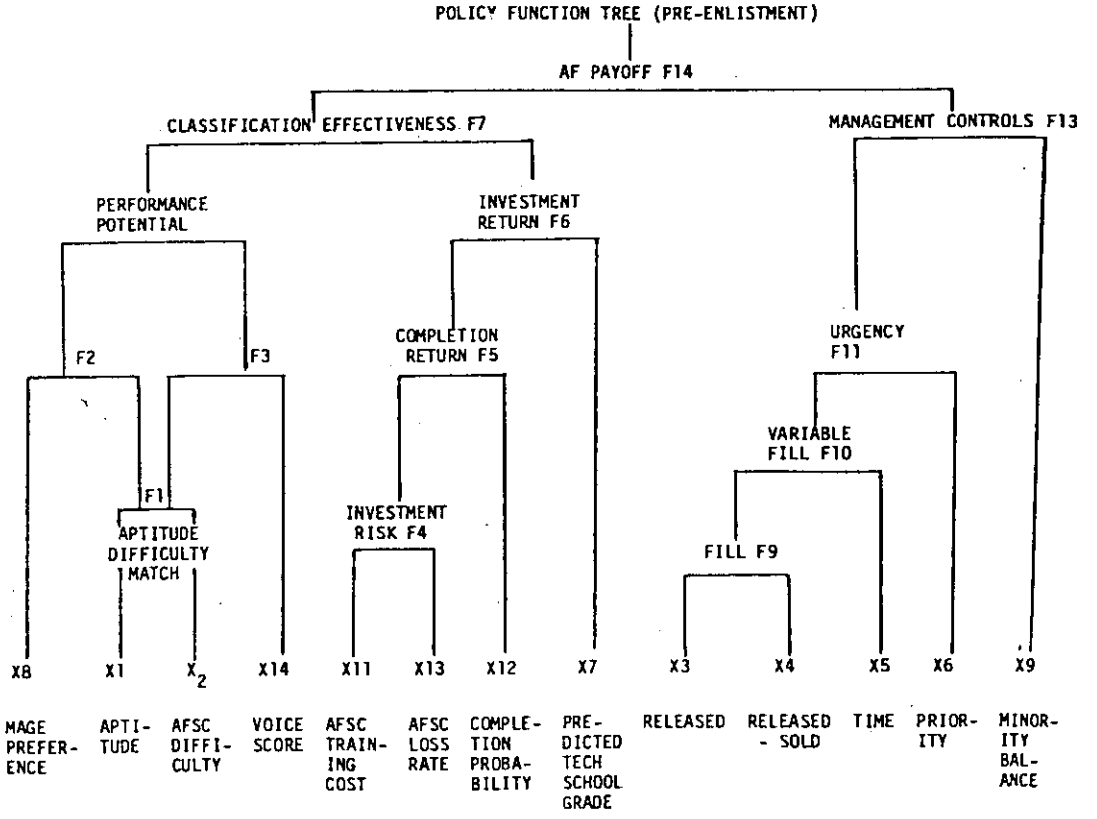
R&D Resource Allocation Hierarchy



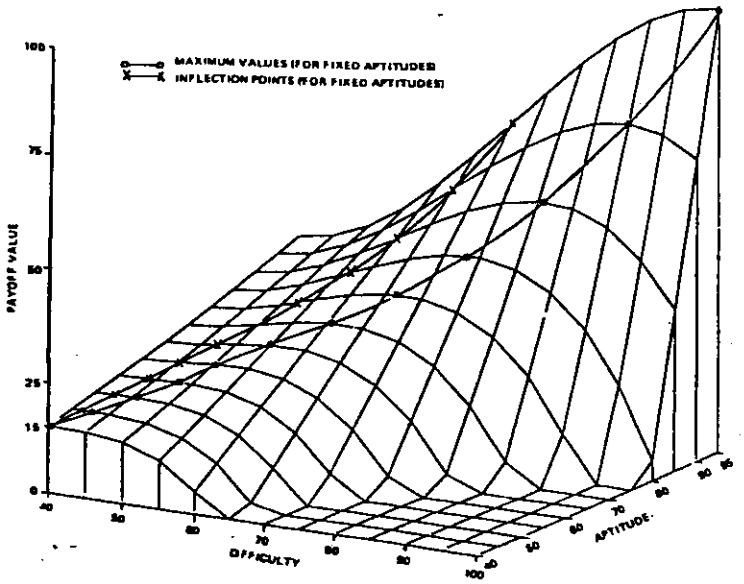
HIERARCHICAL INTERACTION OF INPUT VARIABLES

RESEARCH EVALUATION & INVESTMENT DECISION SYSTEM (REIDS)

In another example, policy specifying has been used to define a hierarchy for the initial classification of Air Force recruits.



In this hierarchy, the experts in conjunction with the model makers at AFHRL, have defined the variables which are important in determining the payoff to the Air Force of classifying each airman into each AFSC. The experts then specified the hierarchy of functions that combines the variables in a pair-wise fashion. The individual's aptitude is matched with the difficulty of the job, using function F1. The surface shown below relates aptitude to difficulty. Then the airman's preference for an AFSC is matched with F1 to form Performance Potential. When the Vocational Interest Career Examination (VOICE) is available in the AFEES, this score will be substituted for Mechanical, Administrative, General, or Electronics (MAGE) preference to form Performance Potential (using F3 in place of F2). The second portion of the hierarchy yields a function output called Investment Return (F6) and as can be seen from the variables input to it, this hierarchy represents the amount of return on the invested dollar that management can expect to get from an airman. The variables at the lowest level of this hierarchy are AFSC Training Cost, which is the cost of being trained into this AFSC, and the Loss Rate for that AFSC. These two are combined to form an Investment Risk function (F4), with a high risk value for any given AFSC representing either a large investment or a high loss rate. This function is then combined with the applicant's probability of completing the first term of enlistment as calculated using the Likelihood Function Estimation (LIFE)



Pay-Off Function of Aptitude and Difficulty.

Model. The output of this function, Completion Return (F5), tends to give a higher payoff for an individual with a high Completion Probability in a high-cost/high-risk AFSC, and a low payoff to the low Completion Probability individual. In the hierarchy, Performance Potential and Investment Return are combined by function F7 to yield Classification Effectiveness. The last function, F14, provides the overall payoff to Air Force by combining Classification Effectiveness with Management Controls.

SUMMARY

The primary distinctions between the three methods of decision theory modeling discussed here are:

SUMMARY OF METHODS

- POINT ALLOCATION
  - Attempts to produce a policy model by allocating percentages of total points to each of the X's.
- JUDGMENT ANALYSIS
  - Attempts to predict behavior of a judge by computing a weighted function of the X's.
- POLICY SPECIFYING
  - Attempts to produce a policy model by specifying a functional relation among the X's.

Point Allocation has the following properties:

PROPERTIES OF METHODS

POINT ALLOCATION

- EASY TO USE AND EASILY UNDERSTOOD
- MAY BE ADEQUATE FOR SOME POLICIES
- DIFFICULT TO EXPRESS COMPLEX POLICIES
  - DOES NOT USE INTERACTIONS OR NON-LINEARITIES
- MAY NOT MODEL JUDGMENT BEHAVIOR

Judgment analysis has these properties:

PROPERTIES OF METHODS

JUDGMENT ANALYSIS

- MODELS JUDGMENT BEHAVIOR
  - ACCURACY OF MODEL CAN BE MEASURED
- MODEL EASILY UNDERSTOOD
- METHOD HAS BEEN EXTENSIVELY USED AND RESEARCHED
- JUDGMENT MODEL MAY OR MAY NOT REPRESENT DESIRED POLICY
- REQUIRES EXTENSIVE JUDGE PARTICIPATION
- TOO MUCH INFORMATION MAKES JUDGING DIFFICULT
- MODEL ACCURACY AFFECTED BY MISSING INFORMATION, FUNCTIONAL FORM AND INCONSISTENCY

Policy specifying can be summarized as follows:

Policy specifying can be summarized as follows:

PROPERTIES OF METHODS

POLICY SPECIFYING

- EXPERT INTERACTS WITH MODEL MAKER
- EXPERT CAN HANDLE MUCH INFORMATION DUE TO PAIR-WISE HIERARCHY APPROACH
- COMPLEX POLICIES CAN BE READILY EXPRESSED
- DESIRED POLICIES CAN BE ELICITED AND REPRESENTED
- REQUIRES SOME EXPERT PARTICIPATION
- HIERARCHY IS DIFFICULT TO DEFINE AND MAY NOT BE UNIQUE
- SENSITIVITY OF EXTREME VALUES AND FUNCTIONAL FORMS IS NOT ALWAYS APPARENT
- METHOD IS BEING USED OPERATIONALLY BUT MUCH RESEARCH NEEDED

Hierarchical Policy Specifying shows much promise, but it also requires a significant amount of research to better define the method. Alternate procedures for specifying the functions and sensitivity analysis of the specified functions are two research projects which will be started in the near future. In the meantime, other applications for the specifying methodology are being pursued, including an advanced enlisted assignment system and an officer initial classification system.

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