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A MULTILEVEL SALARY COMPENSATION MODEL USING GOAL PROGRAMMING (*)

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Abstract. — This paper deals with a systematic procedure for analyzing annual merit salary adjustments at each of the five functional levels of a large business organization. Goal programming techniques are used to analyze and accomplish the desired corporate objectives based on priority factors. Goal programming models for the various functional levels are formulated, solved, and interpreted, together with descriptions of model limitations and implementation. The models facilitate planning, decision making, and control by providing management information.

Keyword: Goal Programming.

Résumé. — Cette communication a pour objet de définir un mode opératoire systématique destiné à l'analyse du rajustement annuel des salaires basé sur le mérite, et ce aux cinq niveaux de fonctionnement d'une grande entreprise. Diverses techniques de programmation des objectifs seront appliquées à l'analyse et à la réalisation des objectifs de l'entreprise établis selon les facteurs prioritaires. Des modèles de programmation des objectifs aux différents niveaux de fonctionnement seront formulés, explicités et interprétés conjointement à une présentation des limites ainsi que de l'application du modèle. Ces modèles ont pour but de faciliter le planning, la prise de décision et le contrôle en fournissant des renseignements à la direction.

Mot clé : Programmation des Objectifs.

1. INTRODUCTION

An examination of the literature pertaining to the use of goal programming in the personnel function, reveals a number of contributions. Some of these contributions concern aggregate personnel decision making, such as determining the number of people to hire to adequately staff an operation [8] and determining the optimal mixture of employees possessing a variety of skills [12, 15, 18]. Some of these contributions concern the development of a model that will solve a multitude of personnel problems [3] while others deal with very specific personnel decision making topics such as promotion [17].

The subject of merit compensation systems can be divided into two general categories. One major category concerns the use of money as a motivator [2, 5, 19]. This issue is dealt with in the literature by the development of compensation

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models that are uni-level within an organization. Specifically the models concern merit compensation for upper level employees [7, 16] while others concentrate on lower level workers [9]. The second major category represents a collection of solution processes that deal with a narrow or specific topic of personnel management. Such topics as salary equity [1, 6, 20] and job evaluation [11, 13] are typical of this collection. No aggregate plans or processes for installing an aggregate merit increase system was discernible for existing literature.

The purpose of this paper is to introduce a systematic procedure for analyzing annual merit pay increases at the various levels of a large organization using a goal programming model. The name of the organization will be withheld to ensure corporate security. A goal programming approach at various hierarchy levels of decision making allows responsible management to see the effects of possible decisions before they are finalized. The criteria upon which decisions are made will be unique to a given organizational level. Goals and the priorities set on the accomplishment of those goals reflect management's interpretation of personal and organizational needs. To simplify the approach, rate increases are given to each subordinate functional unit expressed as a percentage of the total annual salary expense (straight rate – without overtime) rather than a dollar amount.

Merit rate review processes are lengthy and time consuming. They require thoughtful judgement by management and can do much damage to subordinates morale if not properly administered. Management must be aware of the criteria affecting wages, some of which are:

- 1) the prevailing wage within a skill group;
- 2) the ability of the firm to pay for wage increases;
- 3) how the cost of living is affecting employees;
- 4) productivity of employees;
- 5) the bargaining power of employees;
- 6) firm job requirements (present and future), and the like [4].

At the higher management levels, the ability of the firm to pay increased salaries will be of paramount importance, while at the supervisory level rewarding individual performance and potential will be of greatest importance. The procedure discussed in this paper provides a means by which decisions on wage increases can be quickly tested to see if the desired results are produced.

The general procedure consists of five steps. First, it will be necessary to determine what resources are available (i.e., pool dollars available for distribution). Second, what desirable results (goals) would we like to accomplish (i.e., a specific rate increase to a certain group). Third, of the desirable results,

what priority is set on the accomplishment of each. Fourth, the problem is formulated for goal programming solutions. Finally, the fifth step involves the evaluation of the resulting goal programming solutions to determine if they are acceptable. If the results are not favorable, priorities may require reordering or goal adjustment before a new solution can be obtained.

To illustrate this procedure, the remainder of this paper presents an application of a merit pay increase throughout an organization. The next section describes the organizational structure of the firm, followed by the application of the model.

2. FUNCTIONAL LINE ORGANIZATIONAL STRUCTURE

An example of a functional line organizational structure is shown in figure. Four companies are under Zeta Corporation. Company A has four reporting company divisions. One of these divisions, Engineering, has six subdivisions. As shown, Subdivision B has Hard-Core Technology Departments and Soft-Core Technology Departments under its functional direction. Although functional and project authority is structured at lower levels, individual salary disbursements are the responsibility of the department manager. A bottoms-up evaluation process is used to form ordinal ratings of department personnel and a tops-down merit adjustment is made based on these evaluations.

Monetary allocation to lower divisions in the form of annual salaried rate increases must be made at each level shown. In addition, the corporate level must decide on the total compensation to be disbursed. Total rate increase to the corporations must take into account both internal and external factors.

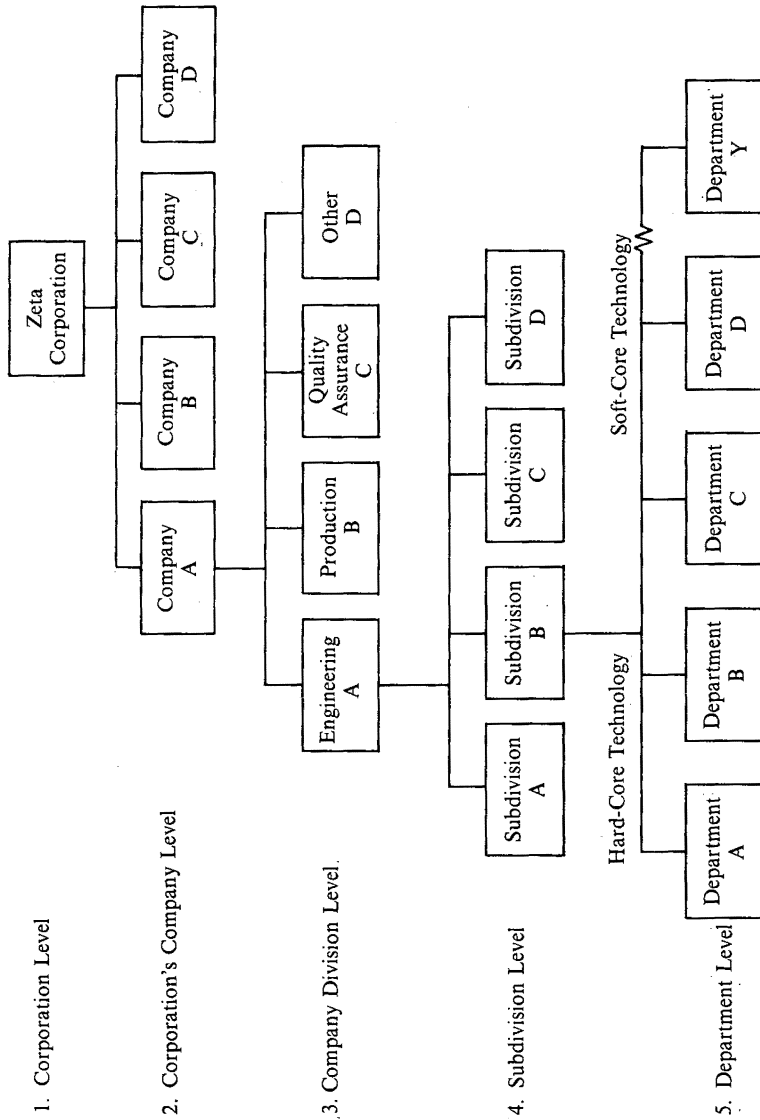
3. THE MODEL

Generalized model

The generalized model for a goal programming problem is:

$$\text{Minimize } Z = \sum_{i=1}^m p_i (d_i^- + d_i^+)$$

subject to $AX + I d^- - I d^+ = B$ and $X, d^-, d^+, \geq 0$ where Z = total deviations from desired goals or objectives; p = priority factors; d^-, d^+ = deviational variables; A = an m -by- n matrix of constants; X = an m -by- n matrix of decision



Functional line organization

variables; I = an m dimensional identity matrix; B = a column vector of m constants.

The following sections of this paper demonstrate how this model is used to allocate a merit pay increase at each level of the organization. In general, the model is formulated to the corporate level to allocate the merit increase to each of the companies. This is followed by a model of the company level for each of its dimensions and this process is contained until the merit pay reaches the individual employee.

Corporate level

Four large companies form the Zeta Corporation. Company A is a large high technology defense contractor. Company B produces military and industrial electronic products. Company C is a computer service supplier which leases computers from the manufacturer and then sells time and service to customers located across the country. Company D manufactures large industrial products. Each company's aggregate salary as a percentage of the corporate total salary expense is given in table I.

TABLE I

Company	Product type	Variables	Relative salary percent
A.....	High technology products	x_1	47.5
B.....	Electronics and simulation equipment	x_2	6.4
C.....	Computer service	x_3	9.8
D.....	Industrial products	x_4	36.3
			<u>100.0</u>

The chief executive officer of Zeta Corporation believes that adequate profitability can be maintained and growth accomplished with an average salary rate increase of 6.5 percent. This proposed rate increase will match the projected cost of living index for the coming year; yet will indicate to customers, the public, and stockholders that the corporation is serious about keeping cost as low as is practically possible in an inflationary period. Since some of the companies within the corporation are heavily involved in defense contracting and these company costs are quite visible, it is necessary to restrict wage increases. However, it is also necessary to give adequate raises to employees to hold their loyalty and attract new personnel.

To formulate the merit pay allocation into a goal programming model the merit increase priorities have to be established. Consistent with the company's desire to maintain the employee loyalty and attract new personnel, the organization wants to allocate the entire 6.5 percent increase (i. e., P_1).

Company A is stable, profitable, and in the midst of the development phase of several new products. Expansion of business in defense contracting has increased demand for personnel in many engineering and manufacturing specialties, thereby driving up wages. To compete for new personnel and hold present staffing, it is estimated that Company A's salary increase should be at least 7 percent (i. e., P_2).

Company C has become a highly successful operation since its establishment a decade ago. The company has constantly expanded and is currently undergoing further expansion with the establishment of new field offices. To support this expansion, salaries must be increased by at least 8 percent (i. e., P_3).

Because of transfers of programming and technical personnel between Company B and Company C, it is felt that Company B should have a rate increase not less than 2 percent under Company C (i. e., P_4). Salaried personnel in Company D should be given at least a 6 percent raise to hold personnel for future expansion (i. e., P_5).

The problem is formulated in goal programming as follows:

$$\text{Minimize } Z = P_1 (d_1^- + d_1^+) + P_2 d_2^- + P_3 d_3^- + P_4 d_4^- + P_5 d_5^- ,$$

subject to:

$$0.475 x_1 + 0.064 x_2 + 0.098 x_3 + 0.363 x_4 + d_1^- - d_1^+ = 6.5,$$

$$x_1 + d_2^- - d_2^+ = 7,$$

$$x_3 + d_3^- - d_3^+ = 8,$$

$$x_3 - x_2 + d_4^- - d_4^+ = 2,$$

$$x_4 + d_5^- + d_5^+ = 6$$

and:

$$x_1, x_2, x_3, x_4, d_1^-, d_1^+, d_2^-, d_2^+, d_3^-, d_3^+, d_4^-, d_4^+, d_5^-, d_5^+ \geq 0.$$

The solution to this problem formulation is presented in table II.

TABLE II
Computational results

Variable analysis		Analysis of the objective	
Variable	Percent	Priority	Under achievement
x_1	7.0	P_1	0
x_2	6.0	P_2	0
x_3	8.0	P_3	0
		P_4	0
x_4	5.53	P_5	0.47

The goal programming solution indicates that all priorities are met with the exception of P_5 . That is, Company D is given a 5.53 percent salary rate increase rather than the preferred 6 percent increase. The solution is subjectively evaluated as acceptable to management; therefore, the rates just computed are allocated to the next lower level (company level).

Company level

Company A has three major operating divisions and several smaller divisions. Salaried employee expense is greatest in the Engineering division, followed by Production, Quality Assurance, and the remaining smaller divisions grouped under one heading as shown in table III.

TABLE III

Division	Division title	Variables	Relative salary percent
A.	Engineering	x_5	71.5
B.	Production	x_6	16.6
C.	Quality Assurance	x_7	3.7
D.	Other (product support facilities, etc.)	x_8	8.2
			<u>100.0</u>

This company has been allocated 7 percent of present cost from the corporation to cover salaried rate increases (i.e., P_6). Engineering has determined that it is not competitive in salary structure and will require a 7 percent annual increase for the next 3 years to attract new engineers and retain present personnel (i.e., P_7). Production volume has been declining for the past

several years and is expected to continue for the next 2 years until new designs go into production. Management sees no reason why production salaried employees should not be satisfied with a 6 percent raise (i. e., P_8). Quality Assurance should be kept within 1 percent of Production on the low side (i. e., P_9). The smaller groups should get at least an 8 percent raise to overcome past inequities in wage allocations (i. e., P_{10}).

The goal programming problem formulation follows:

$$\text{Minimize } Z = P_6(d_6^- + d_6^+) + P_7(d_7^- + d_7^+) + P_8 d_8^- + P_9 d_9^- + P_{10} d_{10}^-$$

subject to:

$$\begin{aligned} 0.715 x_5 + 0.166 x_6 + 0.037 x_7 + 0.082 x_8 + d_6^- - d_6^+ &= 7, \\ x_5 + d_7^- - d_7^+ &= 7, \\ x_6 + d_8^- - d_8^+ &= 6, \\ x_6 - x_7 + d_9^- - d_9^+ &= 1, \\ x_8 + d_{10}^- - d_{10}^+ &= 8 \end{aligned}$$

and:

$$x_5, x_6, x_7, x_8, d_6^-, d_6^+, d_7^-, d_7^+, d_8^-, d_8^+, d_9^-, d_9^+, d_{10}^-, d_{10}^+ \geq 0.$$

The solution to this problem formulation is presented in table IV.

TABLE IV
Computational results

Variable analysis		Analysis of the objective	
Variable	Percent	Priority	Under achievement
x_5	7.0	P_6	0
x_6	6.0	P_7	0
x_7	9.27	P_8	0
x_8	8.0	P_9	4.27
		P_{10}	0

The results of this goal programming solution indicate that all priorities are met, and in addition, Division C will have available a 4.27 percent increase. This is higher than originally proposed; therefore, if management feels it is too large, it could be reduced. Priorities could be redefined or goals adjusted to make some new allocation. In terms of total dollars, the relative salary expense of Company C is small (3.7 percent).

Subsequent levels

At each of the subsequent levels (i.e., divisional, subdivisinal, and departmental) similar models to those developed for the corporate and company levels are developed. Thus, the divisional level model's solution allocates salary rate increases to the subdivisinal units within the company. The subdivisinal level model's solution allocates salary rate increases to the departmental units. Finally, with the development of the department level model the salary rate increases for the individual employees are allocated.

IV. MODEL LIMITATIONS AND IMPLEMENTATION

Model limitations

One of the major limitations of this procedure as well as most goal programming applications is that it requires substantial input of information from the potential users. The model forces decision makers to assess appropriate merit increase rates at each level of the organization. These merit increase goals are then compared with available resources to see if they can be achieved. Since these merit increases would have to have been calculated for evaluation purposes, the task of plugging the data into the model should not limit the use of this procedure severely.

Another limitation is the potential size of the resulting programming model when formulated for a large organization. Because of the large number of interactions required in solving a goal programming problem, existing computer programs cannot solve large problems [10, 14]. This limitation can be overcome by arbitrarily subdividing the number of components existing at a particular level in the organization into smaller units that can then be treated as separate problems.

Implementation

The salary compensation model presented in this paper is solution segmented at each functional allocation level. This top-to-bottom stepwise procedural approach offers conceptual simplicity and ease of implementation. In most organizations, this could represent a "first stage" in the development of a more complex working model. Further model development would require the following model construction:

1. A salary needs forecast model structured for compatibility with the salary compensation model.

2. An integrated salary compensation model which incorporates most of the features of the model discussed in this paper without the need for solution at intermediate levels.

Potential applications

Goal programming has application in merit rate reviews where a large number of organizational divisions exist and many decision factors are involved. Where six or more subordinate functional units exist and many decision factors complicate traditional computational methods, goal programming may provide the quickest and most reliable solution. Policy constraints may exist on merit rate increases per functional unit such as minimum increase, maximum increase, differences between units, multiple of rate increases between units, and combinations of these four items. These are suggested as subject matter of further research in this area.

V. CONCLUSION

A systematic merit rate review procedure has been demonstrated in this paper that can be of value to personnel managers and managers in general. Upon notification of an allocated rate increase for his personnel, a functional unit manager can distribute this increase to subordinate functional units using the techniques just described. It is also possible to test decisions in advance using several assumed rate increases. By adjusting some constraints and/or rearranging priorities, an optimal solution can be derived in a relatively short time even in rather complex rate review situations.

REFERENCES

1. D. W. BELCHER, and T. J. ATCHINSON, *Equity Theory and Compensation Policy*, Personnel Administration, Vol. 33, July-August, 1975, pp. 25-29.
2. A. W. CHARLES, *Theory of Compensation*, Personnel Journal, Vol. 52, January, 1973, pp.12-18.
3. A. CHARNES, W. W. COOPER and J. R. NIEHAUS, *Dynamic Multiattribute Models for Mixed Manpower System*, Naval Research Logistics Quarterly, Vol. 22, June, 1975, pp. 205-220.
4. H. J. CHRUDER, and A. W. SHERMAN, Jr, *Personnel Management*, 5th ed., South-Western Publishing Co., Cincinnati, Ohio, 1976.
5. G. S. CRYSTAL, *Financial Motivation for Executives*, American Management Association, New York, 1970.
6. R. H. FINN, and S. M. LEE, *Salary Equity: Its Determination Analysis and Correlates*, Journal of Applied Psychology, Vol. 56, August, 1972, pp. 292-298.

7. H. FOX, *Top Executive Compensation*, National Industrial Conference Board, New York, 1972.
8. D. A. GOODMAN, *A Goal Programming Approach to Aggregate Planning of Production and Work Force*, Management Science, Vol. 20, August, 1974, PP. 1569-1575.
9. R. K. GOODMAN, J. H. WAKELEY and R. H. RUH, *What Employees Think of the Scanlon Plan*, Personnel, Vol. 49, September-October, 1972, pp. 20-27.
10. J. P. IGNIZIO, *Goal Programming and Extensions*, D. C. Heath and Company, Lexington, Mass., 1976.
11. H. D. JAMES, *Issues in Job Evaluation: The Union View*, Personnel Journal, Vol. 51, September, 1972, pp. 670-678.
12. H. KAHOLOS and D. A. GRAY, *Quantitative Model for Manpower Decision Making*, Omega, Vol. 4, December 1976, pp. 685-697.
13. S. M. KASSEM, *The Salary Compression Problem*, Personnel Journal, Vol. 50, April, 1971, pp. 313-317.
14. S. M. LEE, *Goal Programming for Decision Analysis*, Auerbach Publishers, Inc., Philadelphia, 1972.
15. S. M. LEE, and E. R. CLAYTON, *A Goal Programming Model for Academic Resource Allocation*, Management Science, Vol. 18, April, 1972, pp. 395-408.
16. W. G. LEWELLEN, and H. P. LANSER, *Executive Pay Preferences*, Harvard Business Review, Vol. 51, September-October 1973, pp. 113-119.
17. W. L. PRICE and W. G. PISKOR, *The Application of Goal Programming to Manpower Planning*, Information, Vol. 10, October 1972, pp. 221-231.
18. R. G. SCHROEDER, *Resource Planning in University Management by Goal Programming*, Operations Research, Vol. 22, July-August 1974, pp. 700-710.
19. D. WEEKS, *Incentive Plan for Salesmen*, National Industrial Conference Board, New York, 1970.
20. P. F. WERNIMONT and S. FITZPATRICK, *The Meaning of Money*, J. Appl. Psychology, Vol. 56, June 1972, pp. 220-228.