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A Combined Analytical Method of Job Evaluation

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Abstract

This study includes the design and application of a job evaluation scheme in a metal working company. The first step was the design of a system for determining the weights of job factors from sets of paired comparison decisions by considering only a small sub-sample of jobs. This was carried out in such a way that the rank order obtained from the point rating system duplicated, as closely as possible, that derived from the analysis of overall paired comparison assessments. Then, these factor weights were used to establish a factor plan, which was used to calculate the overall total point values of the jobs, within the sample, on the basis of their job descriptions by making use of the above factor plan, and a final rank order was established according to the total point values.

Six main and 17 sub-factors were chosen for the evaluation. The factors were divided into different levels in order to establish a framework for a factor plan varying from three to seven levels. The factor weights were determined by the Linear Programming Package QSB and, from this, the resultant factor plan was prepared. This factor plan was, in turn, used to evaluate a sample of 54 jobs carried out in the Company. At the end, a final rank order was established for a meaningful base to build up a grade structure.

Key Words: Job Evaluation, Point Rating, Factor Comparison, Factor Plan, Linear Programming.

Birleşik Analitik Bir Metotla İş Değerlendirme

Özet

Bir iş değerlendirme sisteminin tasarımını ve bir metal işleme işletmesinde uygulanmasını konu alan bu çalışmanın ilk aşamasını, sadece anahtar işler olarak seçilen küçük bir iş grubunun ikili karşılaştırma sonuçlarının analiziyle, faktör ağırlıklarının elde edilmesini sağlayan bir sistemin tasarlanması oluşturmaktadır. Bu aşama, amaca uygun olarak, puanlama ve ikili karşılaştırma yöntemlerine göre elde edilen sıralamalar azami ölçüde çakışacak şekilde gerçekleştirilmiştir. Daha sonra, birinci aşamada saptanan faktör ağırlıklarından, işletmedeki tüm işlerin toplam puanlarının hesaplanmasında kullanılacak bir faktör planı elde edilmiştir. Son olarak, hesaplanan toplam puanlara göre nihai bir iş sıralaması gerçekleştirilmiştir.

Değerlendirmede altı temel on yedi faktör dikkate alınmıştır. Faktörler, değişik sayıda faktör seviyelerine ayrılarak, üç seviyeden yedi seviyeye kadar değişen bir faktör planı elde edilebilmesine olanak yaratılmıştır. Faktör ağırlıkları, QSB Paketi içinde yer alan Doğrusal Programlama Programından yararlınılarak elde edilmiş ve bu faktör ağırlıkları kullanılarak faktör planı hazırlanmıştır. Bu faktör planı da, sırasıyla, işletmede gerçekleştirilen 54 işin toplam puanlarının hesaplanmasında kullanılmıştır. En sonunda, işlerin objektif bir şekilde derecelendirilebilmesi için nihai bir iş sıralaması gerçekleştirilmiştir.

Anahtar Sözcükler: İş Değerlendirme, Puanlama Yöntemi, Faktör Kıyaslama Yöntemi, Faktör Planı, Doğrusal Programlama.

Introduction

This study was carried out with the intention of developing a new job evaluation scheme, which would employ two up-to-date techniques of job evaluation (viz., paired comparison and point rating). The objective was to produce **a factor plan** from the analysis of **subjective paired comparison decisions** through a study of a small sample of jobs. This plan would be used, in turn, to determine the point values for each job within the population, which would enable ranking and grading of the jobs, so that it would be possible to construct a payment system based on these grades.

Both paired comparison and point rating produce unsatisfactory results when they are applied on their own. For example, while it is extremely difficult to eliminate biases in favour of certain jobs during the assessment stage of the first, it is almost impossible to obtain a realistic rank order through the application of the latter because of the subjectivity involved in determining **the factor weights.**

This paper gives a detailed account of the design of a system for determining the weights of such factors, and the levels within each factor, from the sets of paired comparison decisions such that the rank order obtained from the point rating system duplicates, as closely as possible, that derived from the analysis of paired comparison assessments.

1. Explanation of the Method

The essential requirement for any job evaluation technique is the preparation of job descriptions. The objective of describing jobs in detail is to establish clearly their work contents and requirements for their satisfactory execution so that subsequent evaluations are not based on assumptions or inadequate understanding of jobs, but on facts.

In collecting information about a job, account is normally taken not only of the content of the job, but also of wider considerations: such as, the purpose of the job; any limits in the accuracy necessary to its proper performance; the environment and conditions of the job; tool and equipment needs of the job; necessary contact with other people; and supervisory as well as financial responsibility.

Although techniques available in this field are large in number and vary in application, it is possible to classify them under four basic categories, as shown in Table 1, according to how jobs are analysed and how the grade structure is developed (Maynard (1971), s. 6.94):

Table 1. Classification of Job Evaluation Techniques

METHOD	NON-ANALYTICAL	ANALYTICAL
BUILD STRUCTURES FROM THE JOBS	**RANKING** Simple Ranking Paired Comparison Single Factor Correlation Time Span	**POINT RATING** Point Rating Job Profile
DEFINE STRUCTURES AND SLOT IN THE JOBS	**CLASSIFICATION** Grade Description	**COMPARISON** Factor Comparison

As was pointed out earlier, the combined method is based on two different techniques (viz., point rating and paired comparison) of job evaluation. Therefore, these techniques are described briefly prior to the explanation of the method:

Point Rating: Point rating is a fairly elaborate technique and usually requires long preparatory work, including detailed analysis and discussion, before it can be applied in any sizeable establishment.

The main stages in introducing point rating are as follows (Maynard (1971), s. 6.102):

1. Obtaining a complete description of the work, which is necessary for the completion of each job.
2. Deciding how many factors or characteristics to employ in assessing the value of the jobs.
3. Defining the number of degrees for each factor.
4. Determining the relative value of each factor.
5. Assigning point values to the degrees.
6. Constructing the job evaluation manual.
7. Determining the point values of each job and constructing a grade structure.
8. Maintaining the system.

The problems confronted in the past show that no one set of factors or characteristics is appropriate to all types of industry and service in which point rating systems are used. As a result, each establishment tends to devise its own set according to its particular requirements and circumstances. Almost invariably, the importance of some factors is reflected in their being more heavily weighted than others. This can be done either by giving a higher maximum of points under one factor than another or, at a later stage, by increasing the value of points by applying a pre-determined multiplier for selected factors.

Paired Comparison: In this technique, jobs are compared in pairs. A job can have a higher ranking than the other of the pair; a lower ranking; or the same ranking with respect to its relative worth to the establishment. Finally, the resultant rank order can be used as a guide for determing the number and limits of pay grades.

The advantages of this technique lie in the ease with which a resultant ranking and a point score for each job can be produced. It avoids some of the difficulties confronted in basing job structures on predetermined factors. It introduces a kind of **built-in-check** while retaining basic simplicity of ranking even though the mathematical techniques, used in developing the factor plan, make it difficult for laymen to understand the details of its application. As more people participate in the applications of job evaluations that use paired comparisons, these ensure, better than other techniques, that the results reflect a consensus of views. One possible disadvantage is the subjectivity involved in assessments, since assessments are based on opinion. Therefore, the analysts must check for consistency and possible bias, so that the effects of this subjectivity are minimised. Another disadvantage could be that the number of comparisons to be made grows too large as the number of jobs under consideration increases. For **N** jobs, the number of comparisons is equal to **N*(N-1)/2**. Techniques have been devised to overcome this difficulty by using a computer program for the analysis. This particular study is another attempt in the same direction, in that it only considers a small sample of jobs that are analysed in pairs to establish **a factor plan**, so that it could be used to evaluate all jobs, including the remaining ones.

Jobs are compared in pairs with respect to their relative worth to the establishment. As a result of each comparison, a job can have a score of "**2**" if it ranks higher than the other "**0**" if it ranks lower; and "**1**" if it ranks the same. A computer program can, then, be written to produce the total score that each job attains and a consistent rank order based on these scores. From this rank order, it is possible to construct an acceptable grade structure by taking into account the total score of each job in the sample. The remaining jobs can then be slotted in the structure by a classification approach.

A more refined method of ranking than that described above is the preparation of **a weighted factor plan**. The conventional technique employed for this is **multiple regression analysis** (Su (1976), s. 31)): The basic approach is to select a number of possible factors and compare the jobs, in pairs, according to each of these factors on a sample of jobs. The data so obtained can be compared with the overall rank order by computer, i.e., the within-factor results are compared with the overall rank order to produce a weighted factor plan. The jobs outside the sample can, then, be assessed more precisely according to the weighted factor values than is possible with the overall ranking approach alone. A proposed pay structure is then fitted to the job structure, with account taken of the going rates of pay outside the establishment.

This study employs a new technique to develop a weighted factor plan, by using a linear programming model to evaluate all jobs. It is a combination of paired comparison and point rating, and drives factor weights for point rating systems based on the decisions of paired comparisons.

Prior to the judging stage of the paired comparison approach, the following procedures should be carried out in the following order (Su (1989)):

1. Jobs to be evaluated should be clearly defined.

2. A representative sample of jobs of all types of work should be selected from the defined population.

3. Detailed descriptions of the sample jobs should be prepared to enable more realistic decisions to be taken in the comparison stage. The descriptions of jobs outside the sample are also required for assessment of their job content or their relative worth to the establishment.

4. Paired comparison forms should be prepared with the job numbers organised to speed up the comparison procedure. All possible combinations of the pairs of jobs are included. When **N** is the number of jobs in the sample and **M** is the number of factors to be considered, the number of comparisons to be made is calculated as follows: **(M + 1)*N*(N-1)/2**

5. Judges should be between six and twelve in number, and should include balanced numbers representing the interests of different organisational groups (viz., unions, management and employees) involved, and be familiar with the jobs.

Having satisfied these requirements the judges are asked to proceed with the comparisons on the basis of an explicitly defined criterion such as the job worth or the relative importance of a particular job. The preferred job is indicated by a tick (V) inserted alongside the job. Ties are indicated by two ticks, one along each job.

The final objective of any job evaluation system is to get the jobs into a rank order on which an acceptable grade structure can be based. This involves two further decisions to be taken by the management-employee committee:

- How many job grades are needed?
- How are grade boundaries determined?

The general opinion would be to have as few grades as necessary in order to provide real and significant pay increases for employees being promoted from one grade to another. For determining the grade boundaries, the following rules are available:

- To have fixed intervals of point scores.
- To perform a cluster analysis.

When a sample of jobs is used to build the grade structure, the remaining jobs are evaluated and slotted in the structure. This is done so, because it is easier to slot a job into an agreed grade structure than into a more detailed rank order, although in some cases (for example, in the application of a factor plan) one may prefer to rank all the jobs first, and then decide on the grade boundaries.

2. Design and Application of the Method

2.1. Collecting and Organising the Data

The data used in the analysis were collected and presented in the form of job descriptions (Tables 2 and 3) and paired comparison assessments (not presented here to save space). They cover a sample of 54 jobs whose encoded job descriptions are given in Table 4. Among these 54, twenty key jobs (viz., the ones that are representative of the jobs in the sample and whose relative values were easily distinguishable) were selected for detailed analysis (Table 5).

Table 2. An Example for the Job Description Forms

JOB TITLE : Cleaning | **JOB NO: 54**	**FACTOR LEVELS**						
FACTORS	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Education (EDU)		V					
Education (EXP)	V						
Manual Ability (MAB)		V					
Physical Ability (PAB)				V			
Initiative (INI)	V						
Responsibility for Own Work (ROW)				V			
Responsibility for Work of Others (RWO)	V						
Responsibility for Safety of Others (RSO)	V						
Responsibility for Materials and Equip. (RME)	V						
Supervisory Responsibility (SUR)	V						
Complexity of Work (COW)	V						
Monotony (MON)	V						
Dynamic Effort (DEF)				V			
Static Effort (SEF)	V						
Unavoidable Hazards (UNH)	V						
Environmental Noise (ENO)	V						
Other Environmental Conditions (OEC)			V				

Table 3. Encoded Form of Table 2

			E	**E**	**M**	**P**	**I**	**R**	**R**	**R**	**R**	**S**	**C**	**M**	**D**	**S**	**U**	**E**	**O**
JOB TITLE	**JOB NO**	**FACTORS**	**DU**	**XP**	**AB**	**AB**	**NI**	**OW**	**WO**	**SO**	**ME**	**UR**	**OW**	**ON**	**EF**	**EF**	**NH**	**NO**	**EC**
CLEAN. JOB	54	LEVELS	1	0	1	3	0	3	0	0	0	0	0	0	3	0	0	0	2

Table 4. Encoded Job Description

JOB NO	JOB TITLE	EDU	EXP	MAB	PAB	INI	ROW	RWO	RSO	RME	SUR	COW	MON	DEF	SEF	UNH	ENO	OEC
1	Moulding Shop Foreman	3	6	5	4	3	5	4	2	4	3	2	1	2	2	5	3	2
2	Assistant Factory Foreman	3	6	5	3	3	5	4	2	3	3	3	0	3	0	5	3	2
3	Mould Fix. And Adjust. Foreman	3	6	5	4	3	5	4	2	4	3	3	0	3	0	4	3	2
4	Pressing Shop Foreman	3	6	5	3	3	5	4	2	4	3	3	0	3	0	3	3	2
5	Head technician (Electric Works)	3	6	5	3	3	5	4	2	3	3	3	0	2	2	5	0	1
6	Powdered Paint Foreman	3	6	5	3	3	5	4	2	3	3	3	0	3	0	1	1	4
7	Assembly Line Craftsman	4	6	5	3	3	5	4	2	3	3	3	1	3	0	1	1	2
8	Enamel Craftsman	3	6	3	3	3	5	4	2	4	3	3	0	3	0	2	1	4
9	Chief Cook	2	6	5	2	3	5	4	2	4	3	3	0	2	0	4	1	2
10	Point Welding Craftsman	2	5	5	3	3	5	4	2	2	3	2	1	2	2	3	2	2
11	Pressing Shop Craftsman	2	5	5	4	2	4	3	2	3	2	2	0	3	0	4	3	1
12	Polishing Foreman	2	6	5	2	3	5	4	1	1	3	2	3	1	3	3	0	3
13	Electrical Technician	3	4	5	4	2	4	3	2	2	2	3	0	3	1	5	0	1
14	Moulding Equipment Operator	3	5	5	3	2	5	0	1	4	0	1	2	2	2	5	3	2
15	Fire Brigade	2	6	5	4	3	5	1	2	4	1	0	0	3	0	5	0	4
16	Materials Procurement Tech.	3	2	3	3	3	5	4	2	2	3	3	0	3	0	1	0	2
17	Mould Equip. Main. Weld. Op.	3	6	5	3	2	5	0	2	4	0	0	1	2	2	2	3	2
18	Screen Process Craftsman	2	6	5	1	2	5	4	0	3	3	1	0	2	2	1	0	2
19	Assistant Factory Operator	3	4	5	3	0	3	0	1	2	0	2	0	3	0	5	3	2
20	Moulder	3	5	4	4	2	4	0	1	3	0	1	0	3	0	3	3	2
21	Press Operator	2	4	3	4	0	4	0	2	3	0	1	3	1	2	5	3	2
22	Cook	1	5	4	1	2	4	2	2	2	2	2	0	3	0	5	1	2
23	Point Welding Machine Operator	2	4	4	3	2	4	0	1	2	0	1	2	2	2	3	3	2
24	Chief Administrative Work	4	5	0	0	3	5	4	2	1	3	3	0	3	0	0	0	0
25	Head of Shift	4	4	0	0	3	5	4	2	4	3	1	0	3	0	0	0	2
26	Wet Paint Pistol User	2	4	5	2	2	3	0	2	1	0	0	2	2	2	5	0	4
27	Quality Control Foreman	4	5	0	0	3	5	4	0	1	3	3	0	3	0	0	0	1
28	Enamelling Inspector	3	4	0	2	2	3	3	0	2	2	2	1	3	0	1	2	3
29	Enamel Baker	2	0	4	4	1	4	0	0	4	0	1	0	3	0	5	0	3
30	Cutting, Forming, Pressing Oper.	3	4	0	2	2	3	3	0	1	2	2	1	3	0	1	2	1
31	Electrician (Installer)	2	5	4	4	1	2	0	2	1	0	1	0	3	0	4	0	1
32	Enamel Miller	3	1	3	3	3	4	0	0	2	0	0	2	3	0	1	3	3
33	Assemble Line Inspector	3	4	0	2	2	3	3	0	2	2	0	3	2	2	1	0	1
34	Refiner Operator	3	2	0	3	3	4	0	0	3	0	0	3	2	2	3	1	3
35	Enamel Pistol User	2	4	4	3	2	4	0	0	2	0	0	1	2	2	0	1	4
36	Surface Preparation Worker	2	1	3	3	1	3	0	1	2	0	1	0	3	0	4	0	4
37	Powdered Paint Pistol User	2	4	4	2	0	3	0	0	3	0	0	3	2	2	0	1	4
38	Box Screen Process Operator	2	4	5	4	0	4	0	0	2	0	0	2	1	2	0	0	2
39	Assemble Line Operator	2	2	3	2	1	4	0	1	1	0	1	3	2	2	1	1	2
40	Polishing worker	1	4	4	2	0	3	0	0	1	0	0	3	1	3	3	0	3
41	Materials In and Out Inspecto	2	3	1	3	0	4	0	0	4	0	3	0	3	0	1	0	1
42	Cleaning and Carrying Job	2	1	2	3	0	3	0	2	0	0	0	1	2	2	5	0	4
43	Keeper	2	2	0	0	3	5	0	2	4	0	0	3	1	2	3	0	2
44	Materials Handling Worker	1	0	1	3	1	4	0	0	2	0	2	0	3	0	1	0	4
45	Screen Process Operator	2	4	5	0	0	4	0	0	2	0	0	0	1	2	1	0	2
46	Enamel Undercoating Inspector	2	1	3	2	3	4	0	0	0	0	1	0	2	2	0	0	1
47	Tea -Making	1	3	4	3	0	3	0	0	1	0	0	0	3	0	0	0	2
48	Loading and Unloading	1	0	0	4	0	3	0	1	1	0	0	0	3	0	3	0	3
49	Enamel Cleaning	2	1	3	1	0	2	0	0	0	0	0	3	2	2	3	1	2
50	Waiter (for tea service)	1	3	4	3	0	3	0	0	1	0	0	0	3	0	0	0	0
51	Waiter (for refectory)	1	2	4	3	0	2	0	0	1	0	0	0	3	0	0	1	2
52	Hanging, Cleaning and Carrying	2	1	2	3	0	1	0	0	0	0	0	1	2	2	0	1	4
53	Cleaning Public Places	1	0	0	3	0	3	0	0	0	0	0	0	3	0	0	0	4
54	Cleaning Job	1	0	1	3	0	3	0	0	0	0	0	0	3	0	0	0	2

Table 5. Endoced Job Description (Key Jobs)

JOB NO	SIRA NO	JOB TITLE	EDU	EXP	MAB	PAB	INI	ROW	RWO	RSO	RME	SUR	COW	MON	DEF	SEF	UNH	ENO	OEC
54	1	Cleaning Job	1	0	1	3	0	3	0	0	0	0	0	0	3	0	0	0	2
52	2	Hanging, Cleaning, Carrying	2	1	2	3	0	1	0	0	0	0	0	1	2	2	0	1	4
51	3	Waiter(for refectory)	1	2	4	3	0	2	0	0	1	0	0	0	3	0	0	1	2
48	4	Loading and Unloading	1	0	0	4	0	3	0	1	1	0	0	0	3	0	3	0	3
44	5	Materials Handling Worker	1	0	1	3	1	4	0	0	2	0	2	0	3	0	1	0	4
40	6	Polishing worker	1	4	4	2	0	3	0	0	1	0	0	3	1	3	3	0	3
39	7	Assemble Line Operator	2	2	3	2	1	4	0	1	1	0	1	3	2	2	1	1	2
38	8	Box Screen Process Operator	2	4	5	4	0	4	0	0	2	0	0	2	1	2	0	0	2
36	9	Surface Preparation Worker	2	1	3	3	1	3	0	1	2	0	1	0	3	0	4	0	4
34	10	Refiner Operator	3	2	0	3	3	4	0	0	3	0	0	3	2	2	3	1	3
33	11	Assembly Line Inspector	3	4	0	2	2	3	3	0	2	2	0	3	2	2	1	0	1
31	12	Electrician (Installer)	2	5	4	4	1	2	0	2	1	0	1	0	3	0	4	0	1
29	13	Enamel Baker	2	0	4	4	1	4	0	0	4	0	1	0	3	0	5	0	3
27	14	Quality Control Foreman	4	5	0	0	3	5	4	0	1	3	3	0	3	0	0	0	1
26	15	Wet Paint Gun User	2	4	5	2	2	3	0	2	1	0	0	2	2	2	5	0	4
25	16	Head of Shift	4	4	0	0	3	5	4	2	4	3	1	0	3	0	0	0	2
23	17	Point Welding Machine Oper.	2	4	4	3	2	4	0	1	2	0	1	2	2	2	3	3	2
11	18	Pressing Shop Craftsman	2	5	5	4	2	4	3	2	3	2	2	0	3	0	4	3	1
5	19	Head Technician (Elec. Works)	3	6	5	3	3	5	4	2	3	3	3	0	2	2	5	0	1
4	20	Pressing Shop Operator	2	4	5	0	0	4	0	0	2	0	0	0	1	2	1	0	2

Each job description contains a job number, a title and a matrix (rows representing factors, columns representing levels within each factor) in which minimum requirements, as demanded by each job, were indicated by ticks in the respective levels of related factors.

Jobs were then encoded in a matrix form (the values following the job titles representing the job levels on respective factors), as shown in Table 3, Table 4 and Table 5, and the latter were analysed with regard to under the following 17 factors (Table 6):

Table 6. Explanations of the Factor Levels

Factors	Levels	Explanations
Education	1	May require ability to read, write, add and subtract. A typical qualification is a diploma from a primary school.
	2	May require a special training above a primary school education. A typical qualification is a diploma from a grammar school.
	3	May require a special training above a grammar school education. A typical qualification is a diploma from a high school.
	4	May require a two years collage education or higher above high school. A typical qualification is a college diploma.
Experience	1	1 month or less than 1 month
	2	1 to 3 months
	3	3 to 6 months
	4	6 months to 1 year
	5	1 to 3 years
	6	Over 3 years
Manual Ability	1	The types of simple tasks requiring little manual ability.
	2	The types of tasks requiring coordination of repetitive manual operations to work with simple machines, equipment and tools.
	3	Although simple machines, equipment and tools are used, the types of tasks requiring coordination of a few components, such as sensitive pieces, while performing work.
	4	The types of tasks requiring moderate manual ability and high degree of coordination of a few components while using complex machines and tools to perform sensitive works.
	5	The types of tasks requiring too much manual ability and very high degree of coordination of a few components while using special tools and machines to perform sensitive works.

Table 6. Explanations of the Factor Levels (Cont'd)

Factors	Levels	Explanations
Physical Ability	1	Physical ability in which the coercive effect of variation of body positions is very little-the use of hand tools or working with light materials.
	2	Physical ability in which coercive effect of body positions is moderate - working with partially heavy equipment and materials.
	3	Physical ability in which coercive effect of variation of body positions is much more difficult because of being under obligation to perform movements working with difficult body positions which require moderate physical effort.
	4	Physical ability in which the coercive effect of body positions is too diffucult because of being under obligation to perform movements-working with difficult body positions which require a high degree of physical effort.
Initiative	1	Routine repetitive work under immediate supervision where the methods have been worked out by others, but requiring decisions like simple comparisons, selections or separations.
	2	Routine work involving the application of established methods but requiring independent decisions according to established standard methods, boundary of quality and tolerances, measurement checking.
	3	Although working methods have been established, the presence of variable and independent work involving the analysis of new problems and developments of related procedures and methods requiring ability to determine proper sequence of work or planning. Works under general supervision or independent.
Responsibility for Own Work	1	Responsibility required in routine and simple jobs or in jobs performed independently of other jobs in which quality of production is not important.
	2	Responsibility required in routine jobs which are performed dependently and in which quality of production has a low level of importance.
	3	Responsibility required in slightl complex jobs in which quantity, quality, time and continuity of production are important.
	4	Responsibility required in complex jobs in which quantity, quality, time and continuity of production are very important.
	5	Responsibility required in very complex jobs in which quantity, quality, time and continuity of production are very important and which require supervision of production.
Responsibility for Work of Others	1	Tasks that involve low levels of responsibility for work of others.
	2	Tasks that involve occasional directions of one or two assistants.
	3	Tasks that involve usual contacts with other departments on matters involving flow of work which has been standardised to a large extent, or supervision of a small group.
	4	Tasks that involve very much responsibility for work of others which may require supervision of a large group.
Responsibility for Safety of Others	1	Represents states in which hazards to the safety of others are likely in common working places.
	2	Represents states in which hazards to the health and/or safety of others are likely to take place while working with small groups with machines, materials and equipment that would possibly cause serious hazards.
Responsibility for Materials, Equipment and Machines	1	Tasks at which loss or damage of materials, products, machines or equipment are not likely to take place.
	2	Tasks at which probability of loss or damage of materials, products, machines or equipment is limited.
	3	Tasks requiring close attention to produce parts or assemblies; and to prevent spoilage of materials or damage to products.
	4	Tasks requiring very close attention due to more complex set-ups where material spoilage and damage to products can not easily be avoided.

Table 6. Explanations of the Factor Levels (Cont'd)

Factors	Levels	Explanations
Supervisory Responsibility	1	Supervising the tasks of a group of up to five workers which require simple and routine checks.
	2	Supervising the tasks of a group of up to six to ten workers which require routine, often simple but sometimes complex checks.
	3	Supervising the tasks of a large group (more than 10 workers) which require non-routine, close and complex checks
Complexity of Work	1	Attention that is required in some simple jobs such as weighing, counting, recording, common oiling and adjusting.
	2	Mental effort that is required to perform and organise work in accordance with the calculated, checked or measured values.
	3	Mental effort that is required to calculate, to plan, to evaluate alternatives, or to check results that may demand professional knowledge.
Monotony	1	Monotony experienced in jobs in a good working environment that are partly repetitive.
	2	Monotony experienced in jobs in a moderate working environment that are partly repetitive.
	3	Monotony experienced in jobs in a poor working environment that are continuously repetitive.
Dynamic Effort	1	Tasks rarely require dynamic muscular exertion.
	2	Tasks that require partial execution in active situations.
	3	Tasks that require continuous execution in active situations.
Static Effort	1	The level of work that rarely requires static muscular exertion.
	2	The level of work that requires a partial execution of static muscular exertion.
	3	The level of work that requires continuous static muscular exertion.
Unavoidable Hazards	1	The level of work that may seldom cause light wounding such as bruises, scratches and slight burns.
	2	The level of work that may cause moderate wounding such as bruises, scratches, sprains, wrenches and medium level burns.
	3	The level of work that may cause grave burns, deep cuts, serious sprains and bruises due to falls.
	4	The level of work that may cause continuous infirmity in one of the organs.
	5	The level of work that may lead to grave events.
Environmental Noise	1	The level of work that is performed in a slightly noisy environment.
	2	The level of work that is performed in a normally noisy environment.
	3	The level of work that is performed in a severely noisy environment.
Other Environmental Conditions	1	Work in the surroundings of which maintenance, repair, light assembly operations are performed.
	2	Work having some intensely disagreeable element that is continuous, such as hot or cold climate, dampness, fumes, vibrations and poor lighting.
	3	Work in outdoor or severe conditions.
	4	Extremely disagreeable working conditions due to continuous and intensive exposure to objectionable elements.

Education: This factor explains the general information required to perform the duties of a job. It represents the minimum level of occupational or technical qualifications necessary to do a job.

Experience: This represent the minimum level of experience, in months or years, required for the proper performance of a job.

Manual Ability: This factor represents the degree of manual ability required for the use of machinery and equipment while the task is fulfilled.

Physical Ability: This factor represents the degree of manual ability required for the use of machines and equipment while the task is fulfilled.

Initiative: This factor measures the ingenuity and original thinking required to meet new situations, devise new courses of action, or complete duties without obtaining the permission of a supervisor or a manager. Considerations should be given here to the extent to which the employee is required to plan or lay out work, make decisions about work methods, or diagnose trouble.

Responsibility for Own Work: This factor defines the level and type of responsibility that is undertaken by a worker while performing his task to meet a specified quality.

Responsibility for Work of Others: This factor measures the responsibility placed on a worker to set the equipment for, to check the work of, and to instruct or to direct other workers.

Responsibility for Safety of Others: This factor stands for the results of possible accidents in a work place. It covers probable injuries that might occur to others through carelessness or improper handling.

Responsibility for Materials, Equipment and Machines: This factor measures the degree of responsibility placed on the worker to prevent loss of, or damage to machines, equipment and tools or to prevent the spoilage, damage and waste of materials and products. It also takes into consideration the probable costs of repair or replacement due to spoilage, damage, etc.

Supervisory Responsibility: This factor represents the level of responsibility of supervising the work of others for checking a group of specific jobs.

Complexity of Work: This factor represents the concentration and attention that a task requires. It only considers the volume of work handled, the length of the work cycle and the sustained attention required.

Monotony: This factor represents the level of monotony that a worker faces because of the repetitive nature of the job.

Dynamic Effort: This represents the level of physical effort that is exerted in tasks that cause the acceleration of blood circulation.

Static Effort: Effort that is exerted in tasks that will increase tiredness and decrease the circulation of blood because of continuous static contraction of muscles due to static loads.

Unavoidable Hazards: This represents the probability of an injury or a work-related illness due to the nature or location of the work that causes unavoidable hazards to the employees health.

Environmental Noise: This represents the level of noise in a working area.

Other Environmental Conditions: This factor represents the surrounding conditions of working environment, other than noise, such as dust, gas, moisture, dirt, air movement, radiant heat, hot and cold climate, vibration, radiation, dazzle, etc.

2.2. Analysis of the Paired Comparison Assessments

The key jobs were compared in pairs on both overall and factorial bases. In comparing two jobs, one might have a higher level than the other, a lower level or the same level. Each job scores 2 if it is in the first category, 0 if it is in the second, and 1 if it is in the third.

A refereeing committee carried out the overall comparisons of the jobs. The factorial comparisons were assessed according to their factor level values as shown in Table 7, where the symbol LHJN stands for the Left-Hand Job Number, ie., the number of the first job to be considered for the comparison process; RHJN stands for the Right Hand Job Number, ie., the number of the second job to be considered for the comparison process; OVA stands for the Overall Assessment; and the others (ie.,***A) stand for the factorial assessments.

Table 7. A Sample to Illustrate the Overall and Factorial Assessments

LHJN	RHJN		OVA		EDUA	EXPA	MABA	PABA	INIA	ROWA	RWOA	RSOA	RMEA	SURA	COWA	MONA	DEFA	SEFA	UNHA	ENOA	OECA
1	2		**0**		0	0	0	1	1	2	1	1	1	1	1	0	2	0	1	0	0

2.3. Determination of Factor Weights by Linear Programming

Factor weights could be calculated either by use of a detailed Multiple Regression Analysis or, more conveniently, by linear programming. The latter of these approaches has been employed in this particular analysis. The objective of using linear programming is completely in line with determining such weights for each factor level (i.e., a factor plan) which, when applied to each job in the sample, would provide an overall rank that which would duplicate, as closely as possible, the overall rank order obtained from the analysis of paired comparison assessments. The variables involved in such an approach are the factor weights, while the constraints are the order of overall paired comparison assessments, and the sum of factor weights must be equal to unity.

Determination of the Coefficients of the Objective Function:

When the distribution of scores attained under each factor is studied, the distribution based on the overall rank order vary considerably from the distributions based on the factorial rank orders. The degree of variance reflects the extent of irrelevance of that particular factor in the establishment of the overall rank order. Therefore, individual factorial sums of absolute deviations between the sums of overall scores and the sums of factorial scores of each key job, at an equal distance in each rank, can be used as the coefficients of the objective function provided that the procedure adopted is a minimisation procedure.

The following analysis, presented in Table 8, illustrates the determination of the coefficient of Factor Education (C1). Determination of the coefficients of the remaining factors has been excluded from the paper; however, the results are presented in Table 9:

Table 8. Determination of the Coefficient of Factor Education

Job Numbers	**Ordered Overall Scores**	**Corresponding Factorial Scores Under Factor Education**	**Absolute Deviations Between the Two Scores**
54	0	4	4
52	2	18	16
51	4	4	0
48	6	4	2
44	8	4	4
40	10	4	6
39	12	18	6
38	14	18	4
36	16	18	2
34	18	31	13
33	20	31	11
31	22	18	4
29	24	18	6
27	26	37	11
26	28	18	10
25	30	37	7
23	32	18	14
11	34	18	16
5	36	31	5
4	38	31	7
Total Absolute Deviations			**148**

Therefore the coefficient of Factor Education (C_1)=148

Table 9. Coefficients of the Objective Function for the Remaining Factors

C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}
128	188	284	108	150	144	152	142	144	144	284	252	260	182	220	340

Determination of the Coefficients of Equality Constraint:

There is only one equality constraint, which can be stated as "the sum of factor weights should be equal to unity". With percentage values this can be written as

$$\sum_{i=1}^{m} X_i = 100$$

where $\mathbf{X}_i$ denotes the percentage factor weights and **m** (17 in our case) denotes the number of factors. Thus, each coefficient in the equality constraint was set equal to "1".

Determination of the Matrix of Level Coefficients:

To determine the values of the matrix of level coefficients (i.e., L values), their effects on the overall paired comparison decisions have been considered. For every win by the first job, the relevant L and L's of the higher levels within that factor are increased by "2", for every draw by "1", and otherwise by "0". The resultant matrix of level coefficients is presented in Table 10. In fact these figures should have been given as percentages of the maximum level coefficients (i.e., each should have been divided by 380), but since our purpose was only to construct the inequalities, these were quite sufficient.

Table 10. Matrix of Level Coefficients

F.LEVELS→ FACTORS ↓	**0**	**1**	**2**	**3**	**4**	**5**	**6**
1	0	28	212	324	380		
2	38	56	90	90	224	306	380
3	100	108	110	138	230	380	
4	56	56	126	290	380		
5	36	118	232	380			
6	0	2	28	108	250	380	
7	196	196	196	250	380		
8	126	192	380				
9	2	110	200	288	380		
10	196	196	250	380			
11	102	238	280	380			
12	244	246	320	380			
13	0	24	172	380			
14	208	208	370	380			
15	76	116	116	220	292	380	
16	240	276	276	380			
17	0	138	268	326	380		

Determination of the Coefficients of Inequality Constraints:

There are 19 (Number of Key Jobs - 1) inequality constraints each formed on the fact that the total score attained by a job should be less than or equal to its immediate higher neighbours in the rank.

Suppose if the rank order were

Job A

Job B

Job C

Etc.

The constraints would be:

Total score of Job C - Total score of Job B ≤ 0

Total score of Job B - Total score of Job A ≤ 0

etc.

Now, given this matrix of level coefficients

((L(i,j), j=1,m(j)), i=1,17) and the column matrix of factor weights (X(i), i=1,17) where the m(j) values are the number of levels in each factor (Table 11), 19 similar constraints can be formed provided that we know the job descriptions (i.e., the levels that each job scores on each factor). This is done by constructing another matrix which is referred to as the Description Matrix (Table 12) and formed by putting 1s in place of ticks and 0s in place of blanks in the original job descriptions. For example, for Job 1, the description matrix is given in Table 12:

Table 11. Number of Levels Within Each Factor (Depicted from Table 6)

FACTORS	**EDU**	**EXP**	**MAB**	**PAB**	**INI**	**ROW**	**RWO**	**RSO**	**RME**	**SUR**	**COW**	**MON**	**DEF**	**SEF**	**UNH**	**ENO**	**OEC**
NUMBER OF LEVELS	5	7	6	5	4	6	5	3	5	4	4	4	4	4	6	4	5

Table 12. The Description Matrix for Job 1

F.LEVELS FACTORS	**0**	**1**	**2**	**3**	**4**
1	0	1	0	0	0
2	1	0	0	0	0
3	0	1	0	0	0
4	0	0	0	1	0
5	1	0	0	0	0
6	0	0	0	1	0
7	1	0	0	0	0
8	1	0	0	0	0
9	1	0	0	0	0
10	1	0	0	0	0
11	1	0	0	0	0
12	1	0	0	0	0
13	0	0	0	1	0
14	1	0	0	0	0
15	1	0	0	0	0
16	1	0	0	0	0
17	0	0	1	0	0

By multiplying the matching values of the Level Coefficients Matrix with that of the Job Description Matrix and summing up all the values so obtained, it is possible to calculate a total score for each job. That is, if S(j) is the total score for job j,

$$S(j) = \sum_{i=1}^{17} \sum_{k=1}^{m(j)} L(i,k) \star D(i,k) \star X(i)$$

where;

j : Job Number
i : An index for factors
k : An index for levels
m(j) : The maximum level for factor j
L : The level coefficient matrix
D : The description matrix
X : The factor weight vector

With these total scores, inequalities can be constructed in agreement with the overall rank order. For example,

$$S(1) - S(2 \leq 0 \rightarrow$$

-184 X(1) - 18 X(2) -2 X(3) +106 X(6) -2 X(13) -162 X(14) - 36 X(16) -112 X(17)≤0

In the same way, it is possible to construct 18 more inequality constraints. The coefficients of these inequality constraints are presented in Table 13:

Determination of the Factor Weights:

Once the coefficients are determined, the problem can be stated in linear programming terms. It is then solved by an LP Package (such as QS or QSB) to calculate the values of the factor weights under the given constraints. The results are shown Table 14.

The first seventeen of the values in the solution set are the factor weights corresponding to the highest levels in each factor taken in order. The remaining values are the slack variables associated with each constraint. In fact, the first 19 of these are the actual slacks representing the point differences between the scores of the key jobs adjacent to each other in the rank order, but the last one is the artificial variable value associated with the equality constraint.

2.4. Designing the Factor Plan

The factor plan consists of an n x m(j) matrix where

n : Number of factors

m(j) : Number of the levels of the jth factor

The numerical values of this matrix have been calculated from the matrix of the Level Coefficients by multiplying them by their corresponding factor weights. The resultant factor plan so formed is presented in Table 15.

Table 13. The Coefficients of Inequality Constraints

CN	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17
1	-184	-18	-2	0	0	106	0	0	0	0	0	-2	208	-162	0	-36	-112
2	184	-34	-120	0	0	-26	0	0	-108	0	0	2	-208	162	0	0	112
3	0	52	130	-100	0	-80	0	-66	0	0	0	0	0	0	-144	36	-58
4	0	0	-8	100	-82	-142	0	66	-90	0	-178	0	0	0	104	0	-54
5	0	-186	-122	154	82	142	0	0	90	0	178	-186	356	-172	-104	0	54
6	-184	184	92	0	-82	-142	0	-66	0	0	-136	0	-148	10	104	-36	0
7	0	-134	-242	-254	82	0	0	66	-90	0	136	60	148	0	40	36	0
8	0	168	242	100	-82	142	0	-66	0	0	-136	76	-356	162	-216	0	-112
9	-112	-34	38	0	-262	-142	0	66	-88	0	136	-136	208	-162	72	-36	54
10	0	-134	0	154	148	142	-54	0	88	-54	0	0	0	0	104	36	188
11	112	-82	-130	-254	114	80	54	-254	90	54	-136	136	-208	162	-176	0	0
12	0	268	0	0	0	-222	0	254	-270	0	0	0	0	0	-88	0	-188
13	-168	-268	130	324	-262	-130	-184	0	270	-184	-142	0	0	0	304	0	188
14	168	82	-280	-70	148	272	184	-254	0	184	278	-76	208	-162	-304	0	-242
15	-168	0	280	70	-148	-272	-184	0	-270	-184	-136	76	-208	162	304	0	112
16	168	0	-130	-224	148	130	184	188	180	184	0	-76	208	-162	-144	-140	0
17	0	-82	-150	-100	0	0	-54	-188	-88	-54	-42	76	-208	162	-72	0	130
18	-112	-74	0	100	-148	-130	-130	0	0	-130	-100	0	208	-162	-88	140	0
19	0	0	0	0	0	0	0	0	-92	0	0	0	-208	162	-160	-140	-130

2.5. Re-evaluation of Jobs and Determination of the Final Rank Order

The point value of each job has been calculated on the basis of its job description with the above factor plan, and a detailed final rank order has been established according to the overall total point values of the jobs (Table 16):

3. Conclusion

In this study, a general package that could be applied to evaluate all types of jobs in all types of establishments, has been developed both the paired comparison and the points rating systems. Six main and 17 sub-factors were chosen for the evaluation. The factors were divided into different levels in order to establish a framework for a factor plan varying from three to seven levels. The factor weights were determined by the Linear Programming Package QSB and from this the resultant factor plan was prepared. This factor plan, in turn, was used to evaluate a sample of 54 jobs in a manufacturing company. In the end, a final rank order was produced to establish a meaningful base to build up a grade structure.

Table 14. The Solution Set for the Factor Weights

VARIABLES	SOLUTIONS %	OPP. COSTS %	VARIABLES	SOLUTIONS %	OPP. COSTS %
X1	5.0	0	S3	0	1.9
X2	6.7	0	S4	37.1	0
X3	7.0	0	S5	3216.2	0
X4	0.0	263	S6	0	1.4
X5	0.0	660	S7	0	0.2
X6	0.0	230	S8	0	0.0
X7	0.0	0	S9	1406.8	0
X8	1.0	0	S10	0	4.2
X9	3.8	0	S11	784.8	0
X10	22.8	0	S12	0	1.1
X11	5.4	0	S13	2008.3	0
X12	8.4	0	S14	0	0.8
X13	4.0	0	S15	0	0.2
X14	8.5	0	S16	0	0.8
X15	12.0	0	S17	3296.6	0
X16	15.1	0	S18	4047.8	0
X17	0.0	460	S19	0	0
S1	2159.3	0	A20	0	-188.3
S 2	0	0.3			

Table 15. The Resultant Factor Plan

FACTORS	FW	L0	L1	L2	L3	L4	L5	L6
EDU	5.0	0.0	3.7	42.7	50.1			
EXP	6.7	6.7	9.8	15.8	15.8	39.4	53.8	66.8
MAB	7.0	18.5	20.0	25.5	42.6	70.3		
PAB	0.0	0.0	0.0	0.0	0.0			
INI	0.0	0.0	0.0	0.0				
ROW	0.0	0.0	0.0	0.0	0.0	0.0		
RWO	0.0	0.0	0.0	0.0	0.0			
RSO	1.1	3.8	5.8	11.5				
RME	3.8	0.2	11.0	20.0	28.8	38.0		
SUR	22.8	117.7	117.7	150.1	228.1			
COW	5.4	14.5	33.9	39.9	54.2			
MON	8.4	54.0	54.4	70.8	84.0			
DEF	4.0	0.0	2.6	18.3	40.4			
SEF	8.5	46.7	46.7	88.1	85.3			
UNH	12.0	24.0	36.7	36.7	69.5	92.3	120.1	
NOI	15.1	95.5	109.7	109.7	151.0			
OEC	0.0	0.0	0.0	0.0	0.0	0.0		

The advantages of such a system are twofold:

• It is more objective than the other systems used for job evaluation.

• It reduces the work by introducing the concept of "Key Jobs", so that the remaining jobs can be evaluated on the basis of their job descriptions, according to the weighted factor values obtained from the analysis of key jobs.

Jobs in metal industries have been evaluated by MESS (the Union of Metal Industries) in Turkey by a Point Rating Method with 12 factors. The factor weights that are used in the study of MESS are exhibited in Table 17.

Table 16. Final Rank Order According to Point Values

JOB RANK	JOB NO	JOB TITLE	POINT VALUE	JOB RANK	JOB NO	JOB TITLE	POINT VALUE
1	1	Moulding Shop Foreman	924	**28**	Enamel Baker	627	
2	2	Assistant Factory Foreman	914	**29**	31	Electrician (Installer)	627
3	3	Mould Fix. and Adjust. Foreman	896	**30**	33	Assemble Line Inspector	606
4	4	Pressing Shop Foreman	873	**31**	34	Refiner Operator	606
5	5	Head technician (Electric	873	**32**	28	Enamelling Inspector	602
		Works)					
6	7	Assembly Line Craftsman	797	**33**	30	Cutting, Forming, Pressing Op.	593
7	6	Powder Paint Foreman	786	**34**	37	Powdered Paint Pistol User	593
8	10	Point Welding Craftsman	786	**35**	32	Enamel Miller	579
9	12	Polishing Foreman	786	**36**	42	Cleaning and Carrying Job	573
10	11	Pressing Shop Craftsman	766	**37**	43	Keeper	573
11	8	Enamel Craftsman	754	**38**	36	surface Preparation Worker	569
12	18	Screen Process Craftsman	747	**39**	38	Box Screen Process Operator	569
13	13	Electrical Technician	744	**40**	39	Assemble Line Operator	569
14	19	Assistant Factory Operator	743	**41**	40	Polishing worker	569
15	21	Press Operator	725	**42**	45	Screen Process Operator	565
16	14	Moulding Equipment Operator	705	**43**	49	Enamel Cleaning	564
17	17	Mould Equip. Main. Weld. Oper	705	**44**	35	Enamel Pistol User	555
18	15	Fire Brigade	703	**45**	41	Materials In and Out	550
18	15	Fire Brigade	703	**45**	41	Materials In and out Inspector	550
19	9	Chief Cook	692	**46**	46	Enamel Undercoating Inspector	493
20	22	Cooker	692	**47**	44	Materials Handling Worker	484
21	24	Chief Administrative Work	687	**48**	48	Loading and Unloading	483
22	20	Moulder	686	**49**	51	Waiter (for refectory)	483
23	23	Point Welding Machine Operator	680	**50**	52	Hanging, Clean. and Carrying	483
24	25	Head of Shift	680	**51**	47	Tea-Making	469
25	26	Wet Paint Gun User	680	**52**	50	Waiter (for tea service)	469
26	27	Quality Control Foreman	680	**53**	54	Cleaning Job	427
27	16	Materials Procurement Technician	671	**54**	53	Cleaning Public Places	425

Table 17. Factor Weights Used by MESS

FACTORS	FACTOR WEIGHTS
SKILL	**40**
Education or essential knowledge	15
Experience	10
Ability	7.5
Initiative	7.5
RESPONSIBILITY	**20**
Res. for equipment and machines	5
Res. for materials and products	5
Res. for production	5
Res. for safety of others	5
EFFORT	**20**
Mental effort	10
Physical effort	10
ENVIRENMENTAL CONDITIONS	**20**
Unavoidable hazards	10
Working conditions	10

The factor weights determined in this study differ to some extent from those used by MESS, but they nearly duplicate the factor weights used in the Nordwürttemberg/Nordbaden Scheme (ILO(1986), s. 165) for metal industry in Germany (Table 18). The differences between various schemes may be due to the following differences:

1. Differences between the companies.

2. Differences between the number of the jobs evaluated.

3. Differences between the job descriptions.

4. Differences between the job groups evaluated.

5. Differences between the methods of selecting the Key Jobs.

Despite the differences in the values of factor weights the final rank orders produced by each study are, more or less, the same.

The accuracy of the overall as well as within-factor paired comparison decisions were assessed by means of determining their coefficients of agreement. The analysis of paired comparison decisions shows that the best consistencies were reached in comparing the jobs according to of supervisory responsibility (97.5%), responsibility for work of others (97.5%) and initiative (95.3%); where as the least consistencies were on the factors of monotony (51.1%), physical ability (47.0%) and other environmental conditions (16.3%).

The results of a job evaluation scheme are affected by the jobs evaluated, the factors used to evaluate the jobs and the subjective judgements of the bodies making the evaluation. For this reason, it is vital that job evaluations be based on accurate job information, and key jobs be representative of all the jobs in the establishment in which the evaluation is going to be made. The factors and levels within each factor-should

• be sufficiently comprehensive to cover all the essential aspects of jobs while avoiding overlapping and double counting

• be limited in number to avoid the inclusion of minor significance

• be capable of being clearly defined, and

• not be biased on any form of implicit discrimination.

Table 18. Comparison of Factor Weights

Main Factors	**Values Obtained by MESS** (%)	**Values Obtained in Nordwürttemberg /Nordbaden** %	**Values Obtained in This Study** (%)
Skill	40	18.9	18.7
Responsibility	20	24.2	27.8
Effort	20	26.4	26.4
Environmental Cons.	20	30.5	27.1

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