PROJECT RANKING USING ELECTRE III

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Ranking and selecting projects is a relatively common, yet often difficult task. It is complicated because there is typically more than one dimension for measuring the impact of each project and more than one decision maker. This paper considers a real application of a project selection methodology for Northern Generation, a division of the Electricity Corporation of New Zealand using the ELECTRE III method. This method has several unique features not found in other solution methods; the concepts of outranking and the use of indifference and preference thresholds. The ELECTRE III method is explained and applied to a project selection problem. Experience with the methodology shows that ELECTRE was well received by the decision makers and, importantly, provided sensible and straightforward project rankings.

Keywords: multiple criteria, decision making, project ranking.

1 Introduction

Each year the Northern Generation division of the Electricity Corporation of New Zealand (ECNZ) plan capital and maintenance programmes to enhance and maintain generating plant. The list of proposed projects invariably exceeds financial targets; therefore an annual task is to reduce the number of projects to be within the total budget, while remaining cognizant of the various strategic and tactical objectives represented by these projects. In this application we consider only minor projects with a value less than NZ$250,000. Historically, the process of fund allocation for the eighty or so minor projects consisted of the Group Accountant coordinating a meeting of about thirty sponsors and stakeholders, where each project was presented by its sponsor. Arguments for and against projects were typically subjective (and often emotive) with little quantitative analysis. A goal of Northern Generation was to introduce a more objective methodology for the allocation of minor project funds.

This decision problem is a multiple criteria problem. The financial objective of maximizing net present value (NPV) is not the only relevant criterion. Other criteria include the strategic contribution of the projects and environmental effects - criteria that cannot easily be incorporated into a NPV framework. Many methods have been developed for solving multiple criteria problems with two of the best-known methods being decision analysis (for example, the SMART approach developed by Edwards (1977) and the analytic hierarchy process or AHP, developed by Saaty (1980)). Both methods are well suited to problems with a finite number of discrete alternatives and both have many practical citations. In this paper we report on the successful use of a very different multiple criteria solution method, called ELECTRE III, for ranking the minor projects at Northern Generation.

2 The project ranking decision problem

This project ranking problem is, like many decision problems, challenging for at least two reasons. First, there is no single criterion that adequately captures the effect or impact of each project; in other words, it is a multiple criteria problem. Second, there is no single decision maker; instead the project ranking requires a consensus from a group of decision makers.

Henig and Buchanan (1996) and Buchanan *et al*. (1998) have argued that good decisions will typically come from a good decision process and suggest that where possible the subjective and objective parts of the decision process should be separated. A decision problem can be conceived as comprising two components; a set of objectively defined alternatives and a set of subjectively defined criteria. The relationship between the alternatives and the criteria is described using attributes which describe, as objectively as possible, the features of alternatives that are relevant to the decision problem. Attributes form the bridge between the alternatives and the criteria. Each criterion attempts to reflect a decision maker's preference with respect to certain feature of the decision problem. These preferences, being specific to a decision maker, are subjective. The elaboration of criteria from attributes is therefore, a necessarily subjective process. In Figure 1 the alternative-attribute-criteria mappings are illustrated, along with the subjective-objective separation.

The goal of structuring the decision problem into objective and subjective components places a clear boundary around the preferences of the decision maker(s). It also allows the evaluation of alternatives (in terms of attributes) to be undertaken as objectively as possible. Moreover, it is generally accepted that any structuring of a decision problem should enhance the decision process and improve the quality of the outcome (for example, Schwenk and Thomas, 1983).

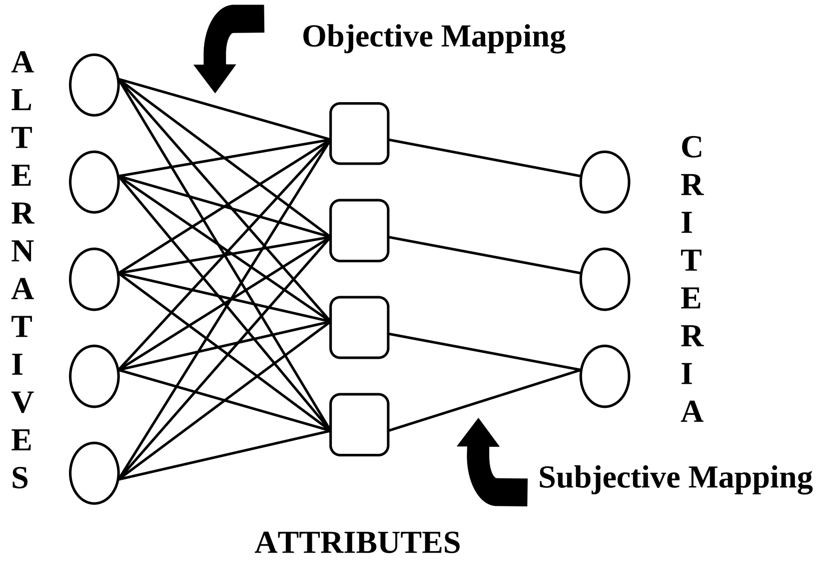

Figure 1. Alternative-Attribute-Criteria Mapping

Using this simple framework of Figure 1 for the Northern Generation project ranking problem, the alternatives (projects) are clearly defined. They are specific projects, such as:

- Penstock and Power Station Area Rock Stabilisation,
- Automatic Generator Control,
- Lower Station Electrical Upgrade, and
- Station Forced Ventilation.

Each project or alternative is defined by its attributes, which are then related to the criteria. After discussion with the management team, the following five criteria were used to evaluate the projects (with some attributes shown in brackets):

FI *financial* (cost and financial return)

SD *solution delivery* (consequences of poor implementation and "proven-ness" of the technology)

SC *strategic contribution* (contribution to the business plan)

RM *risk management* (risk of plant failure and damage following natural disaster), and

EN *environmental* (effect on relationship with resource partners and access to resources).

The criteria, attributes and their relationships to the individual projects were managed using a menu-driven screen within an Excel spreadsheet, as shown in Figure 2.

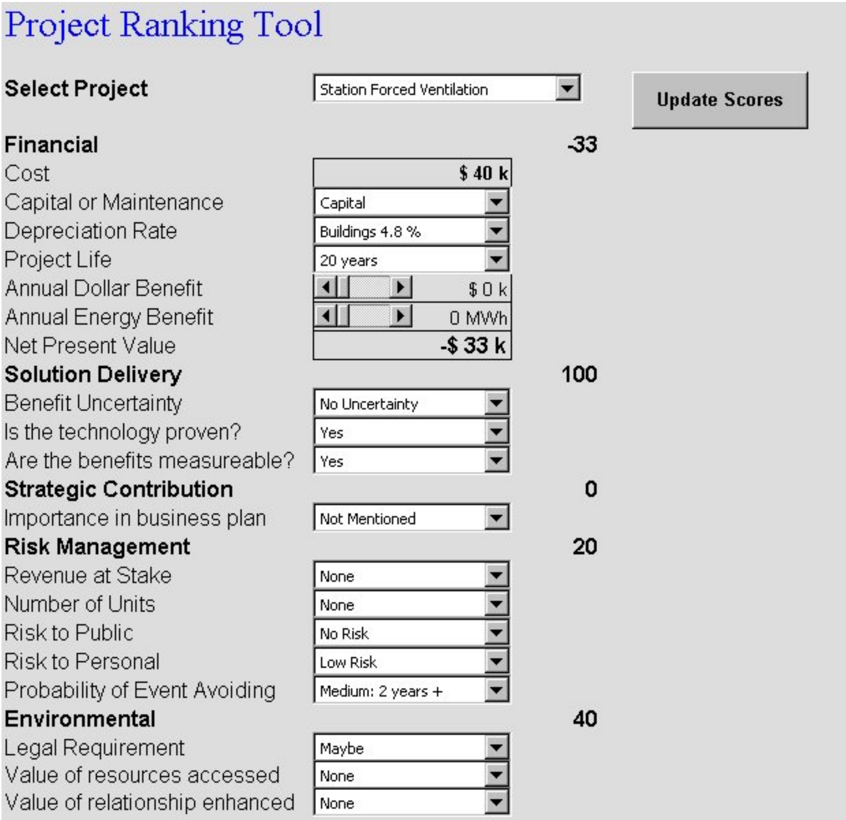

Figure 2. Input Screen for Capturing Project Impact on Criteria

As can be seen from the figure, most criteria were decomposed into simpler, well-defined attribute measures, which were then combined to produce a score for each project for each criterion. The financial criterion, FI, is measured using a net present value (NPV) calculation which uses the inputs of cash flows and energy benefits and the parameters of depreciation, tax and discount rates.

The scores for the remaining four criteria are arbitrarily scaled from 0 to 100; the units of these criteria are not meaningful outside this application. The actual scores for each criterion, with the exception of Strategic Contribution (SC) are defined by a number of attributes that together describe the performance of the project. For example, the risks introduced by a particular project may influence generation revenues, station staff and the public-at-large. The magnitude of generation revenues at risk is then a function of the particular generating station and the number of generating units affected. In each case a logical formula is defined to produce the score for each criteria. This input, where each project is assessed across each criterion, produces a matrix of impacts or performances.

The evaluation of the projects on the attributes was performed as objectively as possible (in co-operation with some experts who were familiar with the project detail). The process of aggregating attributes into criteria involves a first level of subjectivity. At this level, it is important that criteria and the way they are elaborated are accepted by the various decision makers; in the case the sponsors of each maintenance project. The set of criteria was thus validated when they could form a common basis for discussion and evaluation. A second level of subjectivity, taken into account in a later stage of the approach, deals with preference information which reflects, for example, the relative importance of each criterion. Here, each decision maker has the opportunity to express his/her own view so as to confront the different value systems at stake.

Table 1 provides a simple example of a performance matrix, for five projects and five criteria.

Table 1. Performance Matrix

	F	SD	SC	RM	E
Project 1	-14	90	0	40	100
Project 2	129	100	0	0	0
Project 3	-10	50	0	10	100
Project 4	44	90	0	5	20
Project 5	-14	100	0	20	40

In this example, it can be seen that criterion SC had no impact for this subset of projects. The second part of the process was the provision of subjective inputs by the decision makers. That is, preference information - inputs which relate specifically to the criteria and their relative importance. These will be discussed in the following section, after the ELECTRE III method has been introduced.

3 The ELECTRE method

As part of a philosophy of decision aid, ELECTRE (in its various forms) was conceived by Bernard Roy (1968, 1991) in response to deficiencies of existing decision making solution methods. We shall consider only the ELECTRE methods (see also Roy, 1990 and Vanderpooten, 1990 for basic introductions to these methods); Roy's philosophy of decision aid is well expounded in Roy (1993, 1996). Moreover, of the different versions of ELECTRE which have been developed (I, II, III, IV and TRI), we shall use the method specifically referred to as ELECTRE III. All methods are based on the same fundamental concepts, as explained subsequently, but differ both operationally and according to the type of decision problem. Specifically, ELECTRE I is designed for selection problems, ELECTRE TRI for assignment problems and ELECTRE II, III and IV for ranking problems. ELECTRE II is an old version;

ELECTRE III is used when it is possible and desirable to quantify the relative importance of criteria and ELECTRE IV when this quantification is not possible).

A number of factors influenced the specific selection of the ELECTRE III method for the project ranking problem. Originally, it was the intention of Northern Generation to use AHP (Saaty, 1980) to rank projects; however for eighty projects the number of pairwise comparisons required by AHP was prohibitive. Secondly, ELECTRE was originally developed by Roy to incorporate the fuzzy (imprecise and uncertain) nature of decision making, by using thresholds of indifference and preference. This feature was attractive to the management team at Northern Generation. A further feature of ELECTRE, which distinguishes it from many multiple criteria solution methods, is that it is fundamentally non-compensatory. This means, in particular, a very bad score on a criterion cannot be compensated by good scores on other criteria. A further original feature is that ELECTRE models allow for incomparability. Incomparability, which should not be confused with indifference, occurs between any alternatives a and b when there is no clear evidence in favour of either a or b. Finally, the choice of ELECTRE III was also influenced by successful applications of the approach (for example, Roy *et al.*, 1986 and Hokkanen and Salminen, 1997). It should be noted that there are other decision modelling approaches, all with various advantages. For example, Simpson (1996) has compared both SMART and ELECTRE and concludes that, "*there are obvious differences between the methods, but it is not obvious that one method is stronger than the other.*" (p. 928)

Two important concepts that underscore the ELECTRE approach, thresholds and outranking, will now be discussed. Assume that there exist defined criteria, g_j, j=1,2,…,r and a set of alternatives, A. Traditional preference modelling assumes the following two relations hold for two alternatives (a, b) $\in$ A:

a**P**b	(a is preferred to b)	⇔	$g(a) > g(b)$
a**I**b	(a is indifferent to b)	⇔	$g(a) = g(b)$

Consider the performance data of Table 1. For criterion F, the values for Project1 and Project3 are -14 and -10 respectively. Does this mean that Project1 is preferred to Project3? Is the small difference of 4 sufficient reason to make one more preferred than the other? If, for example, a decision maker has to choose between two cups of tea - one with 10 mg of sugar and the other with 11 mg of sugar - could he or she tell the difference? Traditional preference modelling says that because the amount of sugar is not equal, then one will be preferred over the other.

In contrast, ELECTRE methods introduce the concept of an indifference threshold, q, and the preference relations are redefined as follows:

a**P**b	(a is preferred to b)	⇔	$g(a) > g(b) + q$
a**I**b	(a is indifferent to b)	⇔	$\lvert g(a) - g(b)\rvert \leq q$.

While the introduction of this threshold goes some way toward incorporating how a decision maker actually does feel about realistic comparisons, a problem remains. There is a point at which a decision maker changes from indifference to strict preference. Conceptually, there is good reason to introduce a buffer zone between indifference and strict preference; an intermediary zone where a decision maker hesitates between preference and indifference. This zone of hesitation is referred to as weak preference; it is also a binary relation like **P** and **I** above, and is modelled by introducing a preference threshold, p. Thus we have a double threshold model, with an additional binary relation **Q** which measures weak preference. That is:

a**P**b	(a is strongly preferred to b)	⇔	$g(a)-g(b) > p$
a**Q**b	(a is weakly preferred to b)	⇔	$q < g(a)- g(b) \leq p$
a**I**b	(a is indifferent to b; and b to a)	⇔	$\lvert g(a) - g(b)\rvert \leq q$

The choice of thresholds intimately affects whether a particular binary relation holds. While the choice of appropriate thresholds is not easy, in most realistic decision making situations there are good reasons for choosing non-zero values for p and q.

Note that we have only considered the simple case where thresholds p and q are constants, as opposed to being functions of the value of the criteria; that is, the case of variable thresholds. While this simplification of using constant thresholds aids the exposition of the ELECTRE method, it may be worth using variable thresholds especially for the financial (NPV) criterion where the consideration of larger values may lead to larger indifference and preference thresholds.

Using thresholds, the ELECTRE method seeks to build an outranking relation **S**. To say a**S**b means that "a is at least as good as b" OR "a is not worse than b." Each pair of alternatives a and b is then tested in order to check if the assertion a**S**b is valid or not. This gives rise to one of the following four situations:

a**S**b and not(b**S**a); not(a**S**b) and b**S**a; a**S**b and b**S**a; not(a**S**b) and not(b**S**a).

Note that the third situation corresponds to indifference, while the fourth corresponds to incomparability.

The test to accept the assertion a**S**b is implemented using two principles:

- A *concordance* principle which requires that a majority of criteria, after considering their relative importance, is in favour of the assertion – the majority principle, and
- A *non discordance* principle which requires that within the minority of criteria which do not support the assertion, none of them is strongly against the assertion - the respect of minorities principle.

The operational implementation of these two principles is now discussed, assuming that all criteria are to be maximised. We first consider the outranking relation defined for each of the *r* criteria; that is,

$a\mathbf{S}_j b$ means that "a is at least as good as b with respect to the j^{th} criterion," $j = 1,\ldots,r$

The j^{th} criterion is in <u>concordance</u> with the assertion $a\mathbf{S}b$ if and only if $a\mathbf{S}_j b$. That is, if $g_j(a) \geq g_j(b) - q_j$. Thus, even if $g_j(a)$ is less than $g_j(b)$ by an amount up to q_j, it does not contravene the assertion aS_jb and therefore is in concordance.

The j^{th} criterion is in <u>discordance</u> with the assertion $a\mathbf{S}b$ if and only if $b\mathbf{P}_j a$. That is, if $g_j(b) \geq g_j(a) + p_j$. That is, if b is strictly preferred to a for criterion j, then it is clearly not in concordance with the assertion that $a\mathbf{S}b$.

Casually speaking, these concepts of concordance and discordance can be thought of as "harmony" and "disharmony." For each criterion j we are looking to see whether, for every pair of alternatives $(a,b) \in A$, there is harmony or disharmony with the assertion $a\mathbf{S}b$; that is, a is at least as good as b.

With these concepts it is now possible to measure the strength of the assertion $a\mathbf{S}b$. The first step is to develop a measure of concordance; as contained in the concordance matrix $\mathbf{C}(a,b)$, for every pair of alternatives $(a,b) \in A$. Let k_j be the importance coefficient or weight for criterion j. We define a valued outranking relation as follows:

$$C(a,b) = \frac{1}{k}\sum_{j=1}^{r} k_j c_j(a,b), \text{ where } k = \sum_{j=1}^{r} k_j$$

where

$$c_j(a,b) = \begin{cases} 1, & \text{if } g_j(a) + q_j \geq g_j(b) \\ 0, & \text{if } g_j(a) + p_j \leq g_j(b) \\ \dfrac{p_j + g_j(a) - g_j(b)}{p_j - q_j}, & \text{otherwise} \end{cases} \quad , j = 1,\ldots,r$$

Using data from Table 1, we calculate the concordance index for the pair of projects P2 and P5. First, we define the thresholds and weights, as in Table 2.

Table 2. Thresholds and Weights

	F	SD	SC	RM	E
Indifference threshold (q)	25	16	0	12	10
Preference threshold (p)	50	24	1	24	20
Weights	1	1	1	1	1

Thresholds and weights represent subjective input provided by the decision maker, following the objective-subjective separation of Figure 1. Weights used in the non-compensatory ELECTRE model are quite different from weights used in other, compensatory, decision modelling approaches such as the decision analytic approach (SMART) of Edwards (1977). In the decision analytic models, for example, weights are substitution rates and assess relative preference among criteria. Weights in ELECTRE are "coefficients of importance" and, as Vincke (1992) points out, are like votes given to each of the criterion "candidates." Rogers and Bruen (1998b) review existing weighting schemes for ELECTRE and provide a useful discussion of the weighting concept in ELECTRE. For the purposes of this example, we assume equal weights. Care also needs to be taken in determining threshold values, which must relate specifically to each criterion and reflect the preferences of a decision maker. Procedures for choosing appropriate threshold values are addressed by Rogers and Bruen (1998a).

The concordance calculations for projects P2 and P5 are:

$c_1(P2,P5) = 1$, since $129 + 25 \geq -14$
$c_2(P2,P5) = 1$, since $100 + 16 \geq 100$
$c_3(P2,P5) = 1$, since $0 + 0 \geq 0$
$c_4(P2,P5) = 0.333$, since $0 + 12 \ngeq 20$ and $0 + 24 \nleq 20$, then $\frac{24+0-20}{24-12} = 0.333$
$c_5(P2,P5) = 0$, since $0 + 30 \leq 40$.

Therefore $\mathbf{C}(P2,P5) = \frac{(1)(1)+(1)(1)+(1)(1)+(1)(0.333)+(1)(0)}{1+1+1+1+1} = 0.667.$

The value of 0.667 measures the strength of the assertion that P2 is at least as good as P5. Table 3 presents the complete concordance matrix.

Table 3. Concordance Matrix

	P1	P2	P3	P4	P5
Project 1	1	0.80	1	0.80	1
Project 2	0.60	1	0.80	0.90	0.67
Project 3	0.60	0.60	1	0.60	0.80
Project 4	0.60	0.80	0.80	1	0.85
Project 5	0.67	0.80	0.80	0.80	1

These concordance values are easily interpreted. Since equal weights were used, the concordance value is simply the percentage of criteria where one alternative is at least as good as the other. For example, a value of 0.80 for **C**(P1,P2) means that for four out of five criteria, P1 was at least as good as P2. Only for the financial criterion **F** was P2 strictly preferred to P1; that is, the difference exceeded the preference threshold of 50.

Thus far, no consideration has been given to the discordance principle. In the concordance matrix, we have, in a manner of speaking, a measure of the extent to which we are in harmony with the assertion that a is at least as good as b. But what disconfirming or "disharmonious" evidence do we have? In other words, is there any discordance associated with the assertion a**S**b? To calculate discordance, a further threshold called the veto threshold is defined. The veto threshold, v_j, allows for the possibility of a**S**b to be refused totally if, for any one criterion j, $g_j(b)>g_j(a)+v_j$. The discordance index for each criterion j, $d_j(a,b)$ is calculated as:

$$d_j(a,b) = \begin{cases} 0, & \text{if } g_j(a) + p_j \geq g_j(b) \\ 1, & \text{if } g_j(a) + v_j \leq g_j(b) \\ \dfrac{g_j(b) - g_j(a) - p_j}{v_j - p_j}, & \text{otherwise} \end{cases} \quad , j = 1,\ldots,r$$

As shown in Table 4, we assume veto thresholds for each criterion.

Table 4. Veto Thresholds

	F	SD	SC	RM	E
Veto threshold (v)	100	60	2	48	90

Consider criterion F, with a veto threshold of 100. We compare projects P1 and P2. It is clear that:

$$g_{\mathbf{F}}(P2) > g_{\mathbf{F}}(P1) + v_{\mathbf{F}} \qquad \text{or} \qquad 129 > -14 + 100.$$

Therefore, the discordance index $d_F(P1,P2) = 1.00$. A discordance matrix is produced for each criterion. Unlike concordance, no aggregation over criteria takes place; one discordant criterion is sufficient to discard outranking.

For each pair of projects $(a,b) \in A$, there now exists a concordance and a discordance measure. The final step in the model building phase is to combine these two measures to produce a measure of the degree of outranking; that is, a credibility matrix which assesses the strength of the assertion that "a is at least as good as b." The credibility degree for each pair (a,b) in A is defined as:

$$S(a,b) = \begin{cases} C(a,b), \text{ if } d_j(a,b) \le C(a,b) \ \ \forall j \\ C(a,b). \prod_{j \in J(a,b)} \dfrac{1 - d_j(a,b)}{1 - C(a,b)} \end{cases} \qquad \text{where } J(a,b) \text{ is the set of criteria such that } d_j(a,b) > C(a,b)$$

This formula assumes that if the strength of the concordance exceeds that of the discordance, then the concordance value should not be modified. Otherwise, we are forced to question the assertion that a**S**b and modify **C**(a,b) according to the above equation. If the discordance is 1.00 for any $(a,b) \in A$ and any criterion j, then we have no confidence that a**S**b; therefore, $S(a,b) = 0.00$. The credibility matrix for this simple example is:

Table 5. Credibility Matrix

	P1	P2	P3	P4	P5
Project 1	1	0	1	0.80	1
Project 2	0	1	0	0.90	0.67
Project 3	0.60	0	1	0.60	0.80
Project 4	0.25	0.80	0.67	1	0.85
Project 5	0.67	0	0.80	0.80	1

One notable effect of including discordance has been to decrease the strength of the assertion that other projects are at least as good as Project 2, because of the high value for P2 on criterion F.

This concludes the construction of the outranking model. Following the framework of Figure 1, the objective data (which does not include decision maker preference) is captured in the performance matrix. The subjective, preference data is gathered from the decision makers in the form of thresholds and weights. The next step in the ELECTRE III method is to exploit the model and produce a ranking of projects from the credibility matrix. The general approach for exploitation is to construct two preorders Z_1 and Z_2 using a descending and ascending distillation process (respectively) and then combine these to produce a partial preorder $Z = Z_1 \cap Z_2$. The descending distillation process is as follows.

Let $\lambda = \max_{a,b \in A} S(a,b)$. Determine a "credibility value" such that only values of S(a,b) that are sufficiently close to λ are considered; that is, $\lambda - s(\lambda)$. Thus if $\lambda = 1$, let $s(\lambda) = 0.15$. (Detailed computations for the values of s(λ) are provided with the ELECTRE III software (Vallée and Zielniewicz, 1994). Define the matrix T as:

$$T(a,b) = \begin{cases} 1, & \text{if } S(a,b) > \lambda - s(\lambda) \\ 0, & \text{otherwise} \end{cases}$$

Further, define the qualification of each project - Q(a) - as the number of projects that are outranked by Project a minus the number of projects which outrank Project a. Q(a) is simply the row sum minus the column sum of the matrix T. The set of alternatives having the largest qualification is the first distillate of D_1. If D_1 contains only one alternative, repeat the previous procedure with $A \setminus D_1$. Otherwise, apply the same procedure inside D_1. If distillate D_2 contains only one alternative, the procedure is started in $D_1 \setminus D_2$ (unless the set is empty); otherwise it is applied within D_2, and so on until D_1 is used up. The procedure is then repeated starting with $A \setminus D_1$. The outcome is the first preorder Z_1; the descending distillation.

The ascending distillation is carried out in a similar fashion except that the projects with the smallest (rather than the largest) qualification are retained first. For this example, the two distillations give the following preorders, as shown in Figure 3.

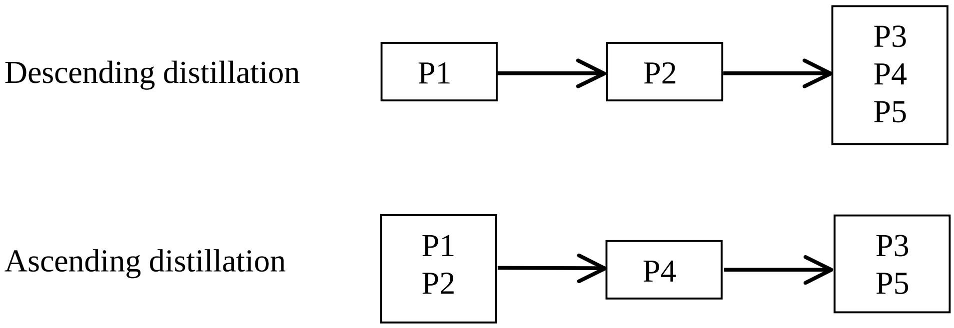

Figure 3. Preorders from Descending and Ascending Distillations

Projects in the same group are ranked equally; they are at least as good as each other. Based on these two preorders, the final order is shown in Figure 4.

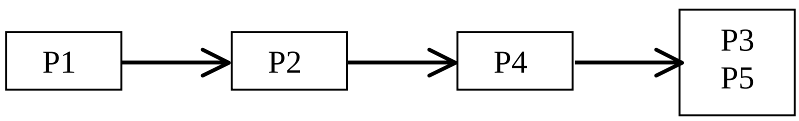

Figure 4. Final Preorder

P3 and P5 are ranked together. A further component of ELECTRE III, as in any good modelling approach is the sensitivity or robustness analysis. Sensitivity of the final rankings to changes in the thresholds and weights, especially, should be undertaken so as to appreciate the robustness of the ranking procedure.

4 Results and Discussion

The goal of Northern Generation was to introduce a more objective (and structured) method for the annual exercise of selecting minor projects to be undertaken. Practically, there was a relatively short time available to develop, communicate and implement such a method for ranking minor projects. It was agreed that the use of ELECTRE III would be as a pilot for 1997.

The process was as follows. An electronic form to collect the relevant data was made available to staff for submitting minor projects. Approximately 80 minor capital and maintenance projects were submitted and the data for each project consolidated into a single spreadsheet. The Business Analyst and Group Accountant reviewed the input data on each project to ensure consistency. Thus, the performance matrix was developed. Concurrently, a presentation was made to project sponsors and stakeholders that addressed the fundamental concepts of the ELECTRE III method, and answered questions. To facilitate the computations of the ELECTRE III method, a simple Visual Basic application within a Microsoft Excel spreadsheet was developed. The aim here was to minimize development cost and time, consistent with the pilot approach. Consequently, the Visual Basic application was indeed simple; discordance and the veto threshold were not implemented and only the descending distillation was used for exploiting the model.

Thresholds and weights were assigned after consultation with decision makers and from this a ranked list of projects was produced. A meeting of project sponsors and stakeholders was then called and the ranked list was proposed as a starting point to identify the cut-off line. Funds requested were 2.3 times the funds available, so a significant cut-off was required. Each project was then quickly reviewed to ensure that it had been properly represented. Projects "below" the line were more thoroughly reviewed to ensure that an essential project was not being dropped in place of another project with more quantifiable benefits. One outcome of the review was a revision of the performances, which lead to a revised ranking of projects. To some extent, this is to be expected in the first use of a new method. The revised list of projects was then submitted and approved for the 1998/99 financial year.

5 Conclusions

As a pilot, the use of ELECTRE III to rank minor projects for Northern Generation was successful. It passed what came to be referred to as "the common sense test." That is, the ranking process and the outcomes were accepted among decision makers at Northern Generation. One reason for the success is, in our view, the structuring of the project ranking problem. Various anecdotal evidence from the authors suggests that the process of structuring a decision problem improves the decision making process and finds favour with the decision makers.

The simple approach described here first has sought to separate the objective components from the subjective components of the ranking problem. The performances - the impact of each project on the five criteria - are objective and should be separate from decision maker preference. This is consistent with the well-known presumption of decision analysis that decision makers have to be able to separate preferences from beliefs. The performance matrix, although uncertain, is a matter of belief, not of preference. The thresholds and weights, however, are subjective. Once the performances are agreed to by all decision makers, then and only then should the subjective inputs of thresholds and weights be processed. The concept of separating the objective and subjective components of a decision problem has proved helpful in this particular instance and should, we believe, be no less helpful in a variety of other decision problems.

The limited sensitivity or robustness analysis undertaken showed that, in general, project rankings were considerably more sensitive to changes in the performances than they were to changes in the thresholds or weights. This is helpful and means that within a relatively wide band of preference, the same projects are considered important. Further, it requires the individual project sponsors to make the effort and ensure that the performance data is both accurate and defensible.

The success of this application has resulted in a more formal use of the ELECTRE III method, including the purchase of the ELECTRE III software, for this and other multiple criteria project selection exercises.

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