A DECISION MODEL FOR POLICY MEASURES

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INTRODUCTION

Decisions concerning activities, both in the personal sphere and in industry and government, may be considered as being the result of a choosing process effected on a collection of possibilities (activities, projects, measures etc.). Any estimable consequences of the possibilities considered can also be included in the choosing process, so that necessary efforts and expected results can both play a role. On some occasions these consequences are objectively determined, measured and quantitatively known. On others, they are subjectively determined, estimated and only qualitatively appraised.

There has been no lack, during the last few decades, of attempts to make the decision making process explicit or to develop decision-making models.
There is extensive documentation concerning the application of such models in many specialized fields, including transport, traffic and traffic safety. In particular, considerable attention has been devoted to cost benefit analyses. This is in fact a book-keeping type of estimation in which the problems lie mainly in assigning financial values to phenomena which have no demonstrable value in terms of money, but can exert such an effect on welfare that they deserve high priority when policies are being drawn up. This is particularly the case where life, health, possibilities of human development, joie de vivre, and comparable human values are at stake.
It is no wonder that it is publications on cost/benefit analysis in the field of traffic safety in particular that give this problem such an emphasis. A decision making criterion that only considers the financial consequences of traffic accidents is difficult to accept, keeping in mind that it is this factor of human suffering caused by injuries and fatal accidents that, while difficult to quantify, gave so much priority to combatting traffic hazards.
The need for an effective decision making technique able to contribute to an optimal determination of priorities is still just as valid. Reactions in the documentation to methods of cost/benefit analysis vary from tense expectation to expressions such as "nonsense on stilts".

In what follows, a decision making model will be put forward that has been developed for solving policy problems in such a way that in addition to the financial aspect, one or more welfare aspects will play a role. The contribution of a measure to general welfare is calculated as the weighted sum of the effects per component of welfare. The ratio of the increase of general welfare to the costs of bringing about the measure is used as a comparison factor.

The cost/benefit model can be regarded as a special case in which all other than financial components are assigned a zero weighting. Three essentially different types of decision making problems can be distinguished:

1. Must a measure be brought into effect or not?
2. Which of two more available measures is preferable?
3. Which of a group of mutually compatible measures or projects should be given priority?

The model has been developed for solving the third type of decision making problem, but can also be useful for the two other types.

1. DECISION MAKING MODELS

1.1. The benefit/cost model

When performing cost/benefit analyses in their usual form, all effects of a measure, both those produced by putting the measure into effect (input effects) and those which are a result of the measure (output effects) are estimated on a money basis. The sum of these financial effects is treated as the decision making criterion. The decision making model can be written in mathematical form:

$$F = \sum_i F_i > 0 \qquad (1)$$

Equation (1) gives the condition for positive decisions. It is usual to split the financial effects of measures into two categories, benefits B_i and costs K_i so that the decision making model can now be written as:

$$B = \sum_i B_i > \sum_i K_i = K \qquad (2)$$

The third form in which this decision making model is represented is:

$$B/K = \sum_i B_i \Big/ \sum_i K_i > 1 \qquad (3)$$

The inequalities (2) and (3) are only equivalent if

$$K > 0 \qquad (3a)$$

This condition needs not always be satified.
It is open to discussion whether certain effects of measures should be considered as positive benefits or negative costs (alternatively as negative benefits or positive costs). During such a discussion at the 51 st. Annual Meeting of the Highway Research Board 1972, Fleischer asserted that this is irrelevant, as condition (2) is not influenced by increasing or decreasing benefits and costs by an equal amount. This argument is not applicable to condition (3). If

$$B > K_o > K > 0 \qquad (4)$$

then (2), (3) and (3a) are satified.
In addition

$$B' = B - F_0 > K - F_0 = K' \tag{5}$$

is also satisfied. Now, however

$$B'/K' = \frac{B - F_0}{K - F_0} < 0 \tag{6}$$

Even if condition (2) is not satisfied, condition (3) is only equivalent subject to the supplementary condition (3a).

Discussion of the category to which given effects should be assigned, as well as the preference for decision making model (2) or (3), can be seen as a difference of opinion between the administrator and his accountant (see figure 1).
From a book-keeping point of view it seems obvious to identify benefits with profit items or debit items and costs with loss items or credit items, and to give preference to model (2). The difference between positive and negative effects is in any case the same as the difference between output and input effects (see figure 2).

$$P - N = 0 - I = F \tag{7}$$

From a policy point of view, it is more logical to link the benefit concept to the aim of the policy and to the output effects of the measure, and the costs to the means, the input effects by which the measure is put into action. As the means are rarely sufficient to realize all the measures which satisfy condition (2) or (3) & (3a), further selection should be applied. The greatest possible total of benefits is obtained from the available means if the measures are realized for which B/K is a maximum. It is evident that model (3) will be preferable from a policy point of view. Although all the effects of the measures considered are expressed in the same units (money), they nevertheless seem to have different dimensions with respect to the purposes and to the means. Both models give only a partial operationalization of the third type of decision making process. The relationships between the two models are illustrated once more in figure 3.

Another problem area of cost/benefit analysis is concerned with reducing the various cost categories to the same denominator. Normally there are isolated and periodic costs: investments, running costs, maintenance, depreciation. The isolated expenses can in principle be converted into annual costs in the form of loss of interest. If the isolated expenses are financed by loans, there are real annual expenses in the form of interest

and redemption, the amount of which can depend on the period during which the measure is in force.
It is equally possible to express all the costs as isolated expenses by adding to the investments an amount set aside from the interest by which periodic expenses can be covered. These procedures are not always real. It is not always possible to raise any required sum on the money market even if one is able to guarantee the interest and redemption. This means that the distinction between isolated and periodic costs pinpoints a fundamental difference. It seems that, in this respect as well, calculations must be performed in more than one dimension, i.e. costs and costs per unit time. The means by which measures can be brought into effect: manpower, raw materials, energy, production capacity etc. usually have a relatively stable cost-price. This does not mean, however, that these means can be available of at will simply by paying the market price.
This multi-dimensionality of the means of production is not brought out in the benefit/cost model. Whenever deficiencies in the means of production become a decisive factor in bringing the measure into effect, the benefit/cost model is inadequate.

1.2. The welfare/cost model

In general, measures and projects carried out by the administrative authorities have an effect on welfare as well as on prosperity. These welfare aspects often constitute primary objectives of the administrative policy, e.g. promoting traffic safety and in particular the reduction of injuries and fatal accidents. There is no objection to considering the financial consequences of these accidents (e.g. medical costs and loss in production) when determining policies, but it is certainly undesirable if considerations are confined to the financial consequences while neglecting the importance which must be attached to preventing human suffering.
If in the first instance we limit ourselves to supposing that besides the financial implications of the measure, just one sort of welfare effect is attained, the effects of the measure can be graphically represented (see fig. 4).
The input effect I is equal to the cost of putting the measure into effect. The output effect O is composed of the benefits B and the welfare increase W.
The resulting effect R of the measure is composed of W and F (= B - K).

Decisions relating to such measures can, analogously with the benefit/cost model (2), be based on the condition

$$W > - \varphi F \qquad (8)$$

The left and right hand side of (8) must have the same dimensions, therefore φ must be expressed in welfare per monetary unit. The fundamental problem is the numerical determination of φ.
It is not yet clear whether a rational basis can be found for quantifying φ.
Two manners of approximation seem worthy of consideration.

1. An attempt can be made to base the determination of a value for φ on ethical norms.
2. An empirical determination can be made of the average value attached to φ in practice and subsequently an endeavour is made to employ this value consistantly.

It can be expected that φ will have a different value for each sort of welfare influence.
W can also have attached to it the significance of a general welfare concept composed of a large number of welfare components. In that case φ has the significance of a weighting factor between a measure for general welfare and a measure for general prosperity. In what follows and unless otherwise stated, costs should be taken to mean the total finicial consequences of the measure. I.e.

$$K = - F \tag{9}$$

Besides the question of what is the best manner of assigning financial values to welfare, it is also profitable to investigate whether such an evaluation is useful for the decision making process and then to what extent a numerical determination of φ is required for the decision making process.
By making use of graphical representations of the measures in terms of welfare against financial effects, it can be determined in which cases a numerical determination of φ is necessary in order to reach a decision, and subsequently, whether in that case there are alternatives to a purely financial estimate.
In fig. 5 the points M_j $(j = 1,2,3,4)$ represent measures or projects. The welfare to be obtained from the measures or projects can be read off the W axis, and the related costs off the K axis. The origin 0 can be regarded as representing the present situation. The vector OM_j represents the change in the situation caused by the measure or project.
It seems natural to assume that the majority of measures contemplated will be represented by a point in quadrant I, i.e. costs are positive and the increase in welfare also.
It can however happen that a measure evokes an unforseen reaction, sets a mechanism in action whereby initial increases in welfare are nullified, sometimes even to the extent that the

measure results in a deminishing of welfare and would thus be represented by a point in quadrant IV.
Measures which in respect of their primary objectives are of the type M_1 can, as a secondary effect, produce such savings in cost that the total effect of the measure is represented by a point in quadrant II.

If abolishing a previously taken measure is regarded as a measure in itself, then abolishing an M_4 measure can also produce an M_2 measure. This will not always be the case; demolition can also be expensive.
Measures represented by a point in quadrant III can occur if the mechanism described above and secondary effects happen simultaneously, or when a measure of type M_1 is abolished.

1.2.1. Decisions on individual measures

It is quite clear that measures of type M_4 should at all times be avoided whereas measures of type M_2 should be implemented within the shortest time possible.
In the case of measures valuable only from a financial aspect, decisions concerning measures of type M_1 and M_3 are straightforward to operationalize.
The first and third quadrant are cut by the dividing line B = K Fig. 3).
For measures represented by points in the area above and to the right of this line $B > K$ and the decision is therefore positive. Below and to the left of this line $B < K$ and the decision is negative. Decision with regard to measures having welfare effects represented by points in the first and third quadrant should similarly be based on their location with respect to the dividing line: $W \doteq -\wp F$. The position of this line is determined by the numerical value of $\wp$. In Fig. 6 the matching dividing lines are drawn for two values of $\wp$. From this it appears that for $\wp = \wp_1$ as well as for $\wp = \wp_2$ the measures M_{11} and M_{31} are accepted. The measures M_{13} and M_{33} are rejected for both values of $\wp$. For $\wp_1$ M_{12} is accepted and M_{32} rejected. For $\wp_2$ M_{12} is rejected and M_{32} accepted.
When taking rational decisions relating to measures represented by a point in the first of third quadrant, it is evident that the numerical value of $\wp$ needs to be established.
The need for such a numerical assignation of a value does not justify conferring any random number.

1.2.2. Choice between a number of mutually exclusive measures

This decision making problem can be formulated as follows:
Given a collection of alternative measures M_j ($j = 1, 2, \ldots\ldots$)

relating to a problem situation that requires improvement subject to the restriction that no combinations of measures are possible.

Question: which alternative is to be preferred.

If it is only a matter of two alternatives, the question of whether M_j is or not preferable to M_k can be replaced by the question of whether the situation arising from introduction of M_k improves further when M_k is replaced by M_j, in which case a decision making problem of type 1 presents itself once again. This is represented in the welfare/cost diagram (Fig. 7) by the question of how M_j is located with respect to the axes now shifted towards M_k.
Evidently measures of the type M_{j4} are rejected by M_k while M_k is in its turn rejected by measures of type M_{j2}.
The preferability of M_k with respect to measures of type M_{j1} and M_{j3} also depends on the value of φ.

If the choice involves a greater number of alternatives, the above outlined criterion can be applied to each pair of measures from the collection so that one of the pair can be rejected on the basis of their relative locations in the welfare/cost diagram. In many cases the number of alternative measures can be considerably reduced in this way, independantly of the value of φ. In the collection of alternative measures which remains, there are only pairs for which the most expensive measure is also the most productive. If this collection is arranged in order of increasing costs and increasing welfare effects, the result will be two perfectly correlating lists.
In many cases this collection can be reduced further by a consideration of the positions of alternative measures in the welfare/cost diagram. There is a second criterion which can lead to rejection of measures independantly of φ (Fig. 8).
If the collection consists of three alternatives, (M_1, M_2, M_3) then M_2 can neither be rejected by M_1 nor by M_3 if the value of φ is undetermined. If M_2 is limited by the conditions

$$W_1 < W_2 < W_3 \qquad (10)$$

$$K_1 < K_2 < K_3 \qquad (11)$$

it is easy to see that values of φ can always be found such that M_3 is chosen before M_2 and M_1, or such that M_1 is chosen before M_2 and M_3. It also appears to be possible to select values of φ such that M_{21} is chosen before M_1 and M_3.
There is, however, no value of φ which gives M_{22} the preference over M_1 and M_3.

M22 can be rejected by the consideration that for each value of φ there is at least one more favourable alternative available. It is not necessary to proceed through every detail of this elimination process. If all alternative measures are represented by a point in the welfare/cost diagram, the result will be a scatter of points (Fig. 9). It is now simple to see that the measure bringing about the greatest increase in welfare M_{Wmax} throws out all more expensive measures ($K > K_{Wmax}$) on the basis of the first criterion. Equally, the cheapest measure M_{Kmin} rejects all measures with lesser effects on welfare ($W < W_{Kmin}$). By the second criterion, the choice will be limited to measures in the segment $M_{Kmin} - M_{Wmax}$ of the broken contour line around the scattered points.

Limiting conditions

So far, no attention has been paid to limiting conditions which could be applied to decisions in addition to a welfare/cost criterion. Examples of such restrictions are:

A. The available budget is limited, the costs of the measure may not exceed the limit set.

$$K \leqslant K^+ \qquad (12)$$

B. A lower limit is set to the welfare which is desired to be obtained.

$$W \geqslant W^+ \qquad (13)$$

A particular case of this is that measures with negative welfare effects are rejected even if they would bring with them considerable savings in costs, i.e.

$$W \geqslant 0 \qquad (14)$$

In decision making problems of type 2, it is useful to include the "zero measure" (M_0, which is a continuation of the existing situation) in with the alternatives.
M_0 will often appear to be the cheapest measure and can therefore not be rejected by the two φ-independant criteria.
As a consequence of the limiting conditions decisions of type 1 can turn out negative due to the measure under consideration costing too much or giving too little benefit.
For decisions of type 2, the limiting conditions effect a reduction in the number of alternative measures. Subsequently, the elimination process described in 1.2.2. is applied.

Limiting conditions are, themselves, also the result of a decision which likewise requires rational motivation. For the time being we shall consider these restrictions as being given, and requiring account to be taken of in the decision making process.

1.2.3. Allotting priorities amongst a collection of measures

A commonly occurring situation when treating a particular problem is that a variety of measures are available and can, in principle, all be applied together, but due to budgetary restrictions cannot in practice all be carried out.
In such a situation, the decision making problem is to perform an optimum choice out of the available measures. By this we mean a choice such that the maximum benefit in welfare is obtained from the available budget.
The choosing process divides the collection of measures into two subgroups, i.e. the selected measures and the rejected measures.
The subgroup of selected measures is optimum if no exchange of measures from this subgroup by arbitrarily rejected measures, leads to an increase in welfare.
There is a simple procedure by which to select an optimum subgroup. The ratio between increase in welfare and the costs entailed is determined for all available measures. The measures are then arranged in order of decreasing welfare/cost ratio (Fig. 10). For each measure, the welfare/cost ratio is represented by the height of the corresponding column, the costs by the width, and the increase in welfare by the area (Fig. 10a).

If the measures are brought into effect in order of decreasing welfare/cost ratio, the horizontal axis represents the cumulative costs, the area beneath the histogram represents the total increase in welfare. In Fig. 10b the total increase in welfare obtained from the available budget can be directly read off. The available budget can be plotted on the cumulative costs axis K_{cum} from the origin. The budget is normally insufficient to complete M_{k+1}. There then remains a minor problem, i.e. to let M_{k+1} expire in favour of one or more measures M_{k+m} or alternatively, to let one or more measures M_{k-m} expire in favour of M_{k+1}.

The procedure described above is only applicable to a collection of measures lying entirely within the first quadrant.
Measures of type M_2 (Fig. 5) receive priority and therefore donot affect the procedure.
Measures of type M_4 have no effect either as they are immediately rejected.
Measures of type M_3 only introduce complications in the procedure if the saving they produce are added to the budget.

The procedure leads to an optimum spending of the budget but does not provide judgement on the optimum size of the budget. The welfare/cost ratio applied to the budget can however be calculated.

1.3. The generalized welfare/cost model

So far, only those measures have been considered which produce welfare effects of just one sort. Many measures, however, are not so specific, they influence many phenomena and influence welfare in a number of dimensions.

Decisions relating to such measures and made on a basis of comparisons of the costs and of the particular aspect of welfare in which one happens to be more interested, detract from the importance devoted to other effects caused by the measure.
If, during the choosing of priorities to be allotted to measures, it is desired to take into account the effect of the measure with regard to several categories of welfare, it can happen that a measure, which from the point of view of one form of welfare is more effective, is less effective from the point of view of another.
The effects on the various forms of welfare will therefore have to be weighed against each other. The several varieties of welfare should be transformed into general welfare with the aid of weighting factors which should in fact express the importance of these forms of welfare for welfare in general.
The relation between general welfare and specific forms of welfare can be represented by the equation

$$W_j = \sum_{i=1}^{n} \omega_i \cdot W_{ji} \qquad (15)$$

in which

W_j : The integral increase in welfare produced by measure M_j
W_{ji} : The specific increase in welfare produced by measure M_j in dimension i
ω_i : Weighting factor for specific increase in welfare in dimension i

The effect of a measure M_j with respect to W_{ji} can be determined by investigation.
The effect of frequently used measures will soon be found by experience.
The value of the weighting factor is determined by the person taking the decision. No scientific opinion can be given concerning the correctness of this value, this is again an ideological or political judgement.

Science can, however, judge the correct handling and consistant application of the chosen weighting factors or determine them by empirical research.

Analogously to the manner in which decisions appeared in a number of cases to be independant of the value of φ, is the possibility, in the situation of measures with welfare effects in more than one dimension, of decisions in a number of cases, independant of the weighting factor ω_i. The case of measures with welfare effects in two dimensions is illustrated in Fig. 11.
It is not the increase in welfare, but rather the increase in welfare per unit of cost, that is plotted on the axes.

$$w_{ji} = W_{ji} / K_j \tag{16}$$

The costs are assumed positive so that w_{ji} and W_{ji} have the same sign. The numerical values of ω_1, ω_2 and φ together determine a boundary line g such that measures represented by a point below and to the left of this boundary line should be rejected. The integral welfare effects w_j are "measured" in a direction perpendicular to this boundary line. It can easily be seen that, independantly of the value of ω_1 and ω_2, M_{j1} always produces higher integral values than M_k and thus is to be preferred, whereas M_k in its turn is to be preferred to M_{j3}. This criterion gives no decision on the relative preferability of M_k with respect to M_k and M_{j2} and M_{j4}. The optimum allocation of a given budget is no longer a theoretically simple exercise with no precise definition of the concept "optimum" which imposes quantitive restrictions to the weighting factors.

2. APPLICATION OF THE GENERALIZED WELFARE/COST MODEL

When discussing the generalized welfare/cost model, it was supposed that determination of priorities based on the model using a group of measures having financial consequences and also an influence on welfare in two or more fundamentally different forms, is only possible if the weighting factors for the several welfare components are determined. Although so far there could be no question of a quantitive determination of these weighting factors, yet priorities were certainly established whenever the problem sketched above occurred.
The statement of the problem can now be reversed, i.e. it can be based on the series of priorities specified for the group of measures considered and on the financial consequences connected with each measure and the effects on the various welfare components, in order to arrive at a determination of the weighting factors. One difficulty with this is that given one

measure a higher priority than another is only a result of there being a difference in effectiveness, but the magnitude of the difference is not expressed by the statement of priority. Putting it the other way round, no equality, but only an unequality is to be derived from the list of priorities.

Given measure M_j a priority higher than M_k is equivalent to the inequality

$$W_j/K_j = w_j > w_k = W_k/K_k \qquad (17)$$

in which $K_j > 0$, $K_k > 0$ while W_j and W_k satisfy (15), so that from (16)

$$\sum_{i=1}^{n} \omega_i \ (W_{ji} - W_{ki}) > 0 \qquad (18)$$

The n unknown values of ω_i can be solved from n equations. As, however, (17) is an inequality, a significantly greater number of these expression will be in general required in order to reach an approximation for the weighting factors.
The possibility of determining the weighting factors in this way was investigated in an actual case. The central problem of the region under investigation was a relatively high degree of traffic hazards. The primary aim of the policy was to drastically diminish the number of traffic accidents with the restriction, however, that other aspects of traffic quality and the infra-structure should not experience any (or at the most, marginal) adverse effects.
Among the most obvious safety measures are some which have an adverse effect on the traffic flow or on ecological aspects of the area.
These effects should be weighed against each other according to a scheme of mutual valuation yet to be finally determined.

2.1. Fitting the model to reality

As both preventative measures and measures aimed at reducing the consequences of accidents are considered, a comparison should be made, from the safety angle, between measures which mainly effect the gravity of accidents and those which mainly effect the total number. Among the measures considered are those which influence travelling comfort and journey times in the area under consideration or along certain routes. The effect of measures on the quality of traffic must be judged at least for these quantities.
Finally, certain measures damage the environment, in particular curring down trees. Environmental aspects can be expressed by a variety of quantities.

It was, however, not clear in advance whether these would play a role in the region investigated. This is why the environmental aspect was just included under the definition of ecological value, thereby holding open the possibility of specifying this value more closely, and possibly in more dimensions, at a later stage.
The analysis was occasioned by the policy's aim of optimally allocating the budget, i.e. according to a set of priorities as expressed in (18) for the case n = 5. The symbols used have the following meanings for the area under investigation:

W_j : integral increase in welfare obtained by measure M_j
W_{jk} : the specific increase in welfare from category k obtained by measure M_j
ω_k : weighting factor for specific welfare from category k
K_j : costs necessary for realizing measure M_j
φ : criterion for effectiveness of measures
W_{j1} : reduction in the number of accidents
W_{j2} : reduction in gravity of accidents
W_{j3} : reduction in travelling time
W_{j4} : increase in travelling comfort
W_{j5} : increase in ecological value.

The specific welfare components are defined such that the weighting factors are positive. Account must be taken of the possibility that certain traffic safety measures may lead to negative values for W_{j3}, W_{j4}, or W_{j5}. Determining the weighting factor ω_k is primarily the responsibility of the policy, whereas determining the specific welfare components W_{jk} and the costs K_j is in the first place a task for the investigation.
The determination of priorities with respect to possible measures cannot be based on measuring specific welfare effects at the locality in which they occur, but on a prognosis of these effects.

The effect of measures will have to be calculated from the connection between characteristics of infra-structure, road network, traffic behaviour and the specific quality characteristics, and from the change the measure under consideration causes in these characteristics. Especially in the case of measures aimed at changes in traffic behaviour, it is often difficult to predict the effect, in particular of measures aimed at changing the factors which generally influence the choice of behaviour but which are not compelling.
Assuming that a degree of experience based on insight into traffic safety problems is implicitly present in practical decision making processes, it can be of direct use to the safety policy to make this experience explicit.

2.2. Test procedure set-up

A number of people in decision making functions and with practical experience in the fields under examination were asked for their cooperation in verifying the model. The participants gave a priority factor on a scale ranging from 1 to 10 to a collection of 143 traffic measures.
The effects specific to these measures with regard to five socially relevant factors mentioned in 2.1 were estimated on a scale ranging from -2 to +2.
Some participants gave cost estimates in monetary units (metric scale) for a group of 77 measures out of the total. At the time the participants were asked to pronounce judgement on various measures according to the above mentioned scales, no previous experience in this method of quantifying judgement was available in this field.
Instructions on how to record their judgements of the measures listed were supplied to the participants in order to avoid too great a divergence in interpreting and using the evaluation scales. This is all that could be expected beforehand, as there was also a lack of experience in this field. It can be assumed that development of an optimally consistant evaluation scheme can only really start after a number of preliminary stages.

The aim of the investigation was to acquire quantitative insight into the way in which dissimilar interests are being weighed against each other in decision on measures which simultaneously influence these different interests.

2.2.1. Summary of data obtained

Evaluation papers were received from six participants concerning the list of 143 measures.
A comparative investigation gave the following results:
a. Not all measures were evaluated by all participants; in most cases because that particular measure was thought not to be applicable to the region under investigation.
b. One participant had mostly reserved judgement about effects on journey time W_3, travelling comfort W_4 and ecological value W_5.
c. One participant had only given a judgement of priority on a relatively small number of measures.
d. Two participants had supplied cost information for a number of measures.

A rough summary of the evaluation papers is given in table 1.

Subsequently, the participants' evaluation papers were compared in more detail, both per measure and per type of effect (category of specific welfare) as well as per category of measures in certain priority classes.

This comparison showed:

e. An identical judgement by all participants on the class of a certain category of specific welfare with certain measures, was an exception. Great differences of opinion also occurred sporadically.

f. There are clear differences between the participants when using the scales of welfare. Although the extreme values of +2 and -2 are used relatively few times, there is a distinct difference in the frequency with which the various services assign extreme values.

g. There are clear similarities between participants' judgement on dominant effects within the reviewed group of measures A positive influence predominates for W_1 and W_2 (number and gravity of accidents) for all participants and for all but one participant for W_4 (riding comfort). There is a predominantly negligible influence for W_3 (travelling time) and W_5 (ecological value). As regards W_3, the remaining measures were evaluated with varying results. For W_5 an unfavourable judgement predominates for the remaining measures.

h. There are clear differences between the participants with regard to applying the scales of priority. Some used predominantly extreme values of the scale, whereas others used middle values.

i. For all participants, a correlation between the evaluation of effects on welfare and the establishment of priorities could be found. This correlation is not perfect.

j. The scales of priority appear to have a zero-level, such that measures with a low priority are seen as harmful, i.e. they would have been turned down even if sufficient means for their realization were available. This zero-level is located at different scale values by different participants.

k. The subgroup of measures for which a cost analysis was given and the group for which this was not the case give on the whole the same picture, both with regard to judging the effect on welfare, and to the placing of priorities. There are, however, some quantitative differences such that different results for each of the two groups cannot be attributed solely to the effects of costs without closer examination.
The idea behind the analyses of the evaluation papers, so far done by hand, was to obtain some guide-lines for more detailed analyses by computer.

3. REMARKS

1. The generalized welfare/cost model, described in section 1, was developed primarily for optimum selection of a set of measures with implications for various aspects of general welfare, from a larger collection.
   Section 2 describes the arrangements for an empirical examination of the utility of the decision making model and of the consequences when applied to an actual case.
   Although the examination has not yet reached a stage at which final conclusions can be drawn up, some indications have already been obtained.

2. The generalized welfare/cost model (G.W.K.) has been developed in such a way that the simple welfare/cost model (E.W.K.) can be seen as a special case.
   The benefit/cost model (B.K.) can be seen as a special case, both of the (E.W.K.) and of the (G.W.K.) model.
   These decision making models statisfy the essential conditions that they do not reject the benefit/cost model which has shown utility in many fields, but limit its application to measures with negligible implications for welfare.

3. The welfare/cost models are based on a concept that enables objectively quantifiable (measurable or countable) effects of measures, and subjective evaluating opinions regarding those effects to be separated.
   Such a separation of quantities is a necessary condition for closer examination of the above mentioned subjective evaluations (weighting factors) and their distribution over a population. If the objective effects and the proposed order of priorities are the quantitatively given data for a sufficiently large number of measures, the weighting factors can be calculated with the help of the model.

4. The welfare/cost models allow inconsistencies to be discovered both within any given concept of a policy and also between concepts of policies.
   The models can also be used to avoid such inconsistencies.

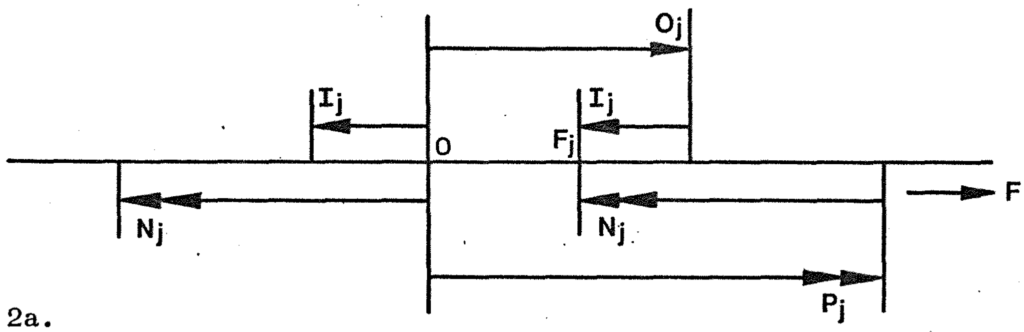
5. The empirical investigation into the utility of the (G.W.K.) model has shown a fairly large, though not perfect, degree of consistency, both within and between concepts of policies, which is a strong indication of genuine correspondance between the model and reality.

6. Inconsistencies found when drawing up priorities compared to priorities which could be calculated on the basis of the weighting factors used, could have been caused by:
   a. imperfection of the decision making model
   b. imperfection of the scales used
   c. imperfection of judgements

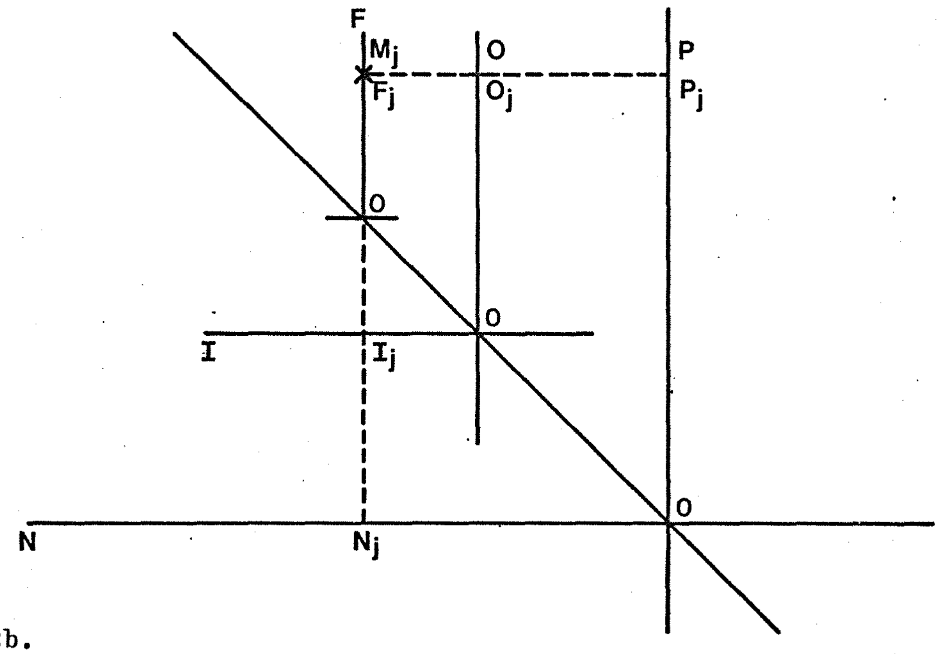
   Research will have to be carried out with the aim of determining what share each of these imperfections may have on the inconsistencies in drawing up the priorities.
   With regard to the decision making model, there are indications that the time within which measures could be realized played an important role in drawing up priorities. The model therefore needs amending in this respect.

	Book-keeping classification		
Administrative classification	Benefits	Detrimental effects	Output
	Savings	Costs	Input
	Positive	Negative	Effect

Fig. 1. Sub-classification of financial effects of measures.



2a.



2b.

Fig. 2. Graphical representation of financial total effect and partial effects of measure M_j on one axis (2a) and on two axes (2b).

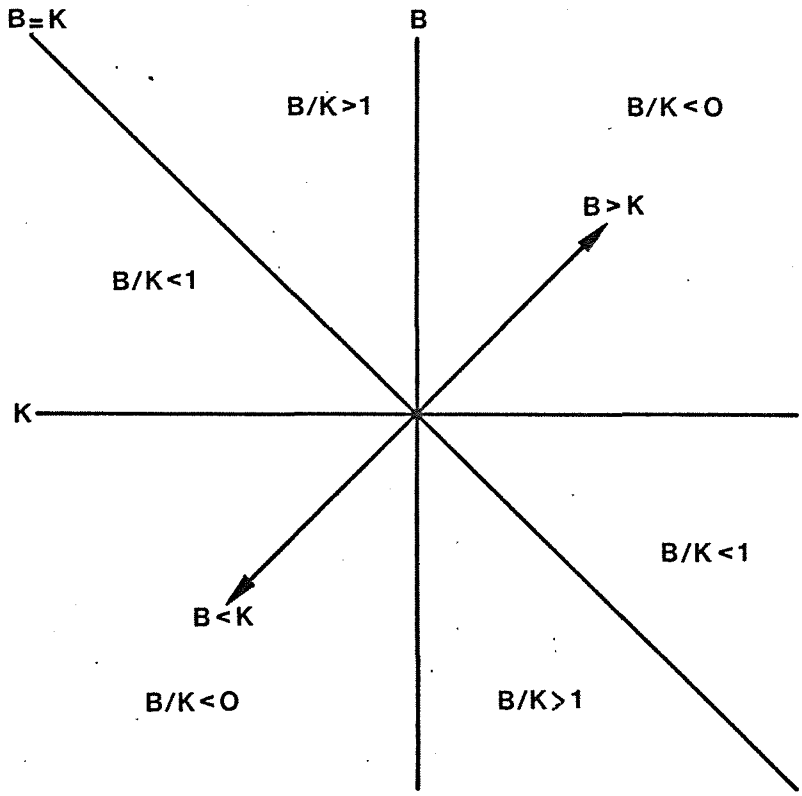


Fig. 3. The relationships between benefit-cost model and benefit/cost model for various values of K and B.

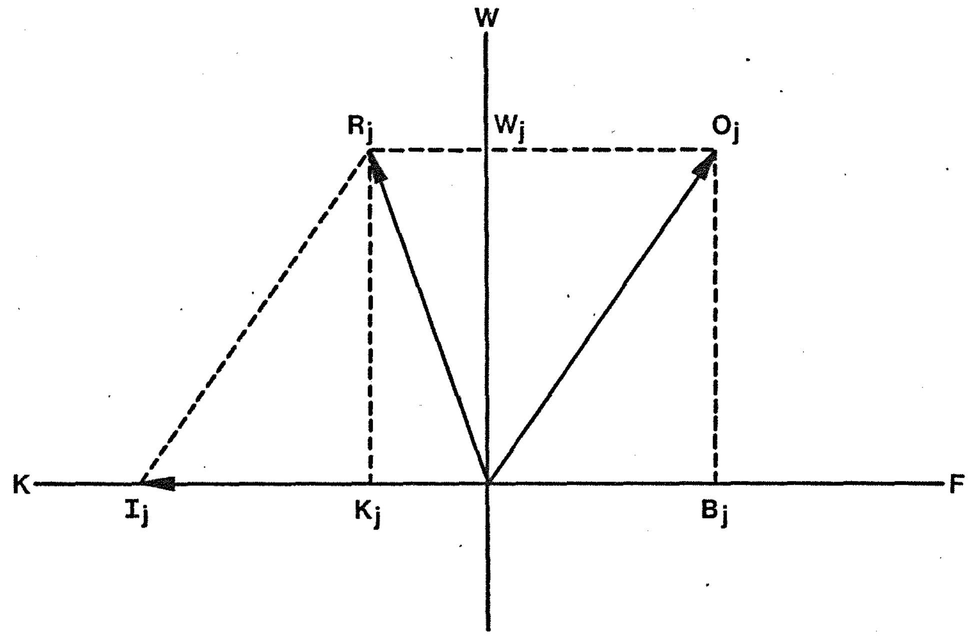


Fig. 4. Graphical representation of the welfare effects and financial effects of a measure M_j.

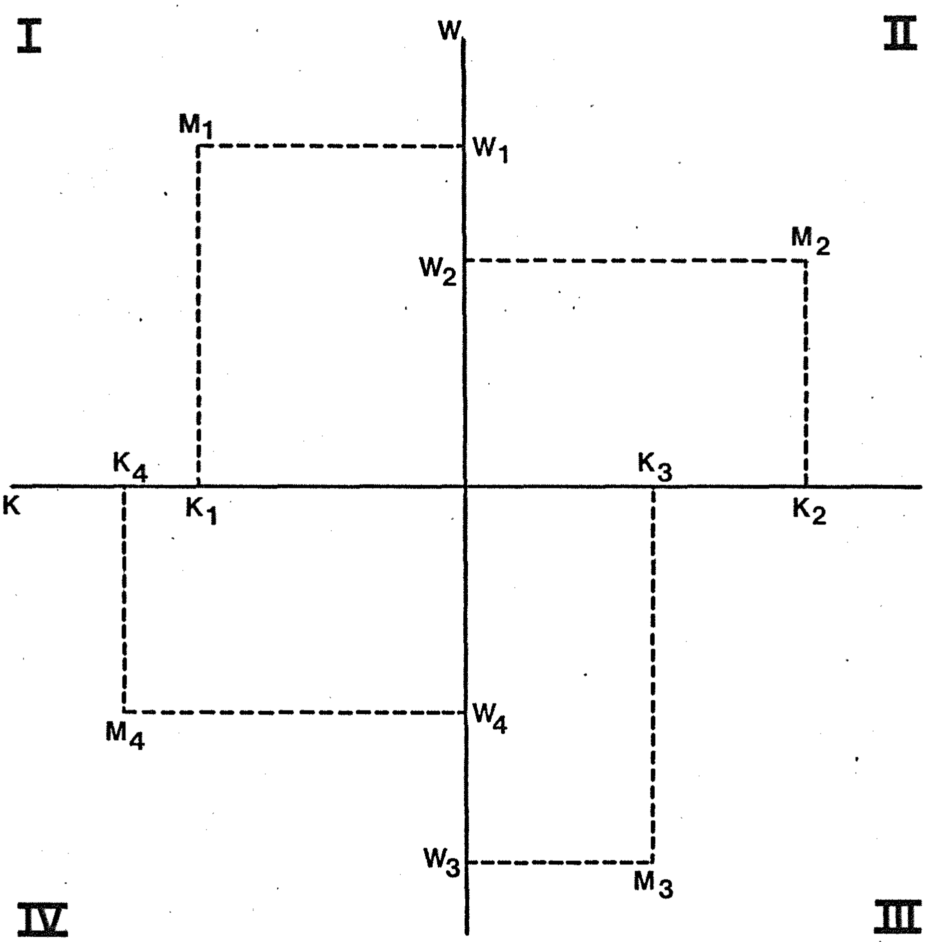


Fig. 5. Representation of measures in the various quadrants of the welfare/cost diagram.

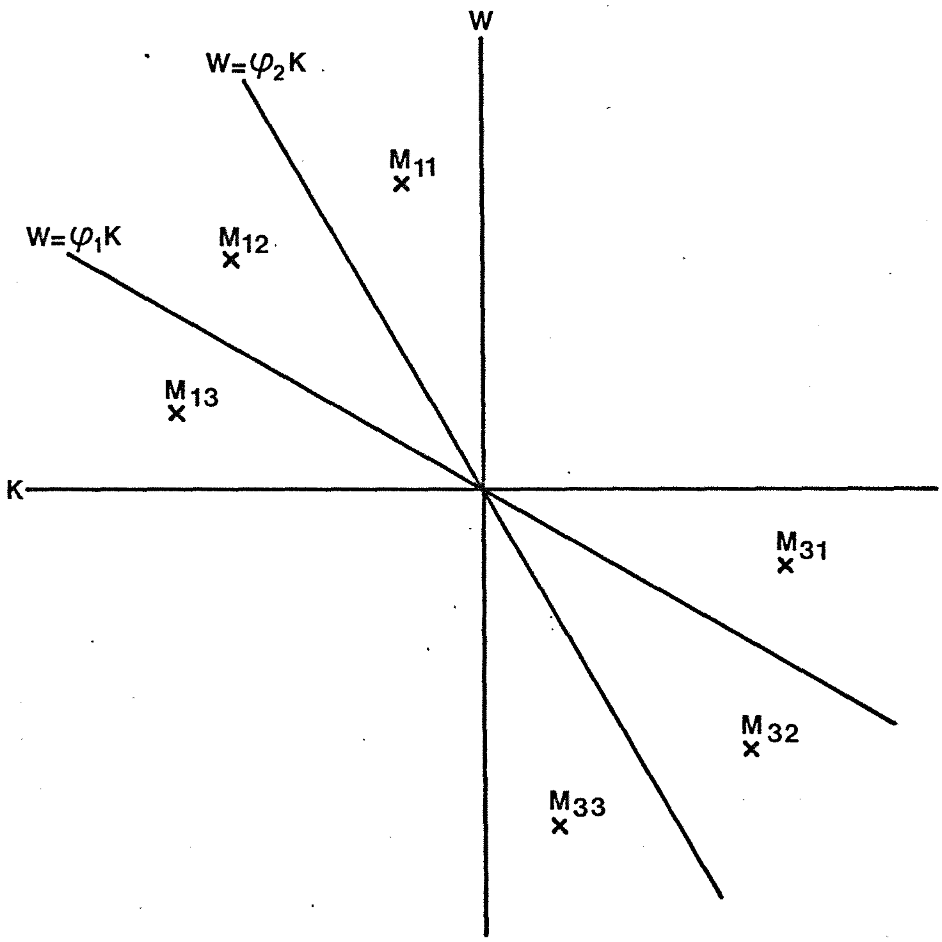


Fig. 6. Evaluation according to different policy guidelines of measures which determine welfare.

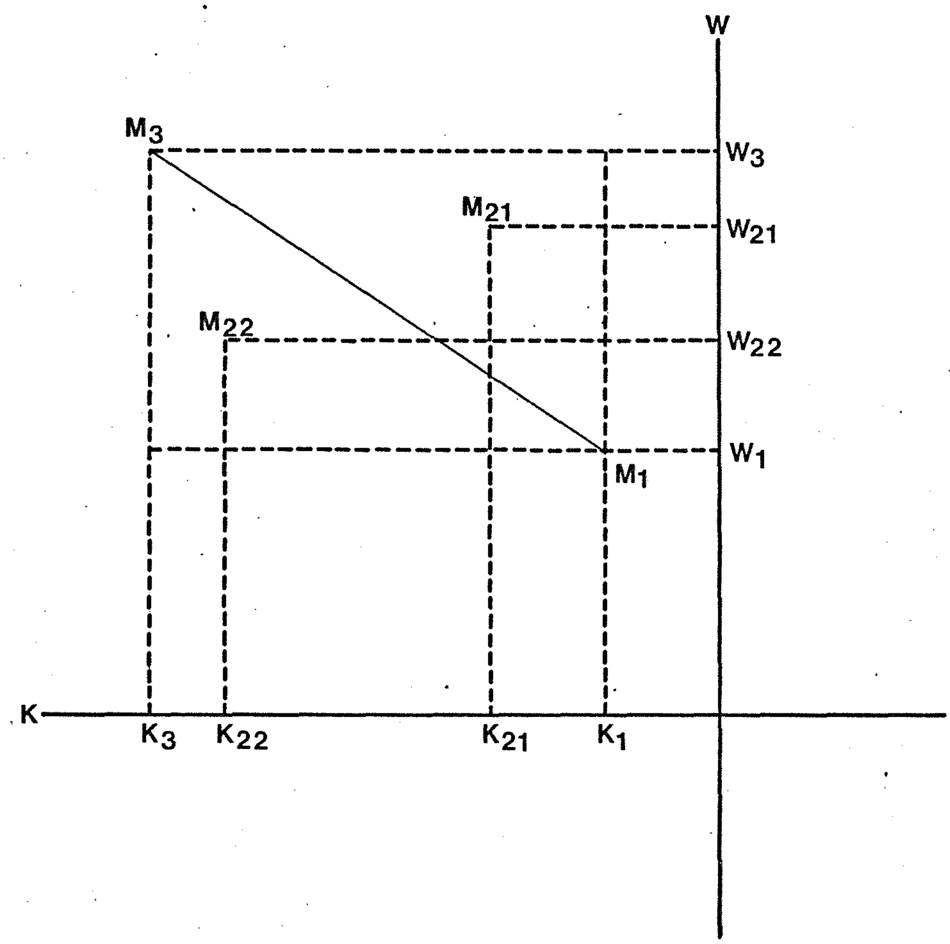


Fig.8. Valuationfree comparison criterion for triplets of mutually exclusive measures.

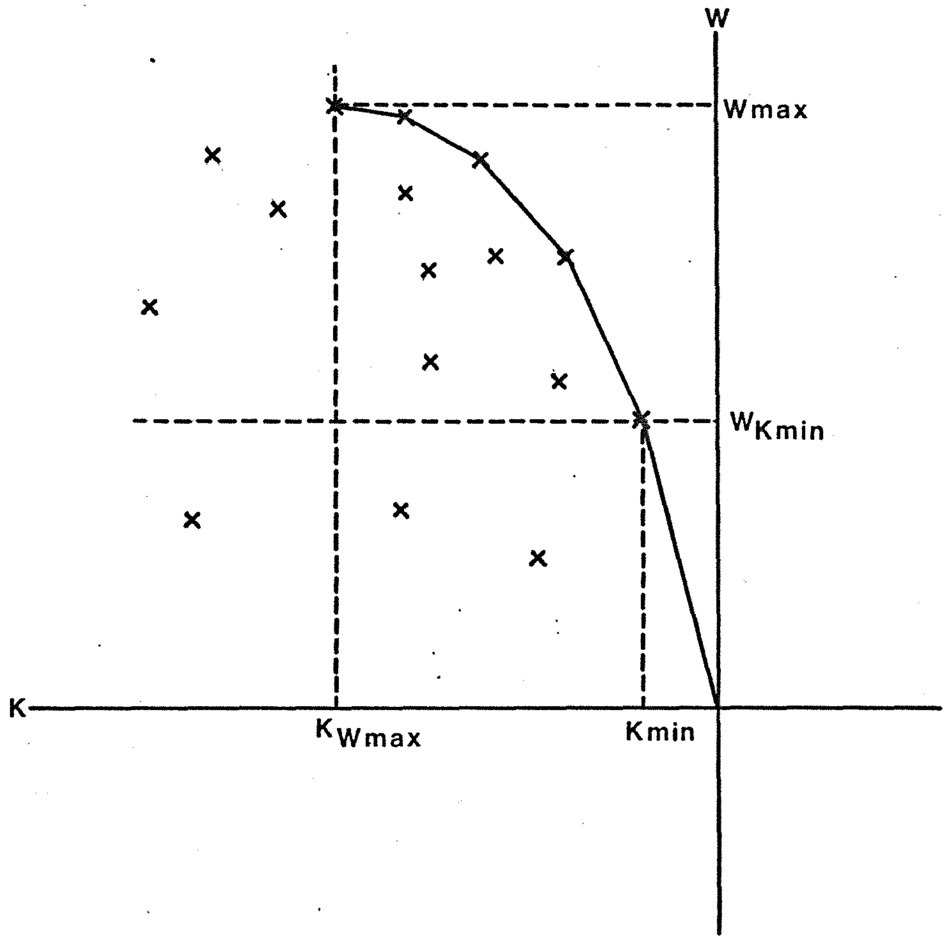


Fig. 9. Effect of valuationfree selection applied to a collection of mutually exclusive measures.

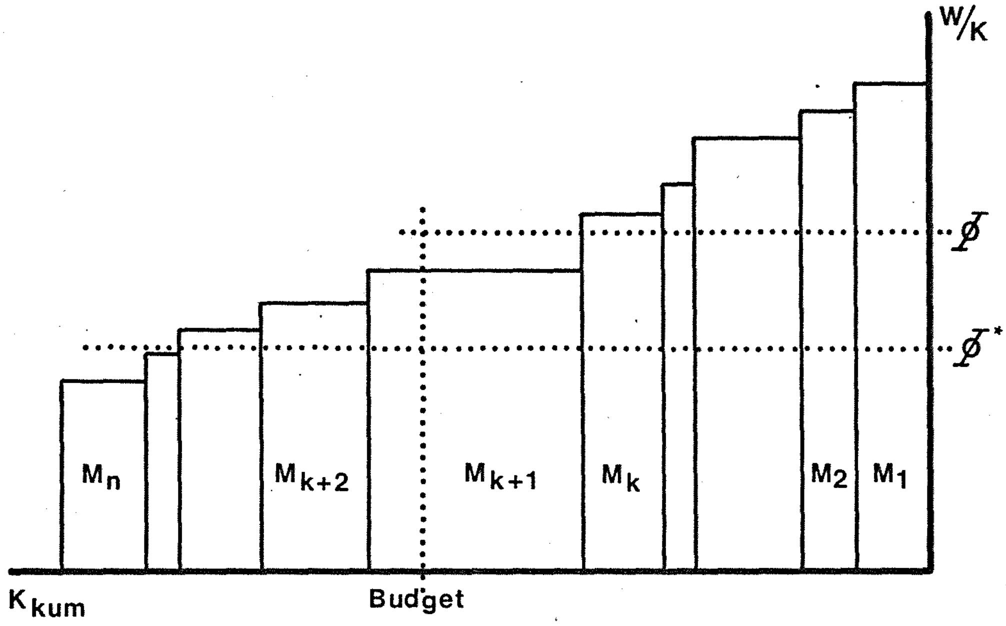


Fig.10a. Collection of measures Mj arranged in order of welfare per unit cost.

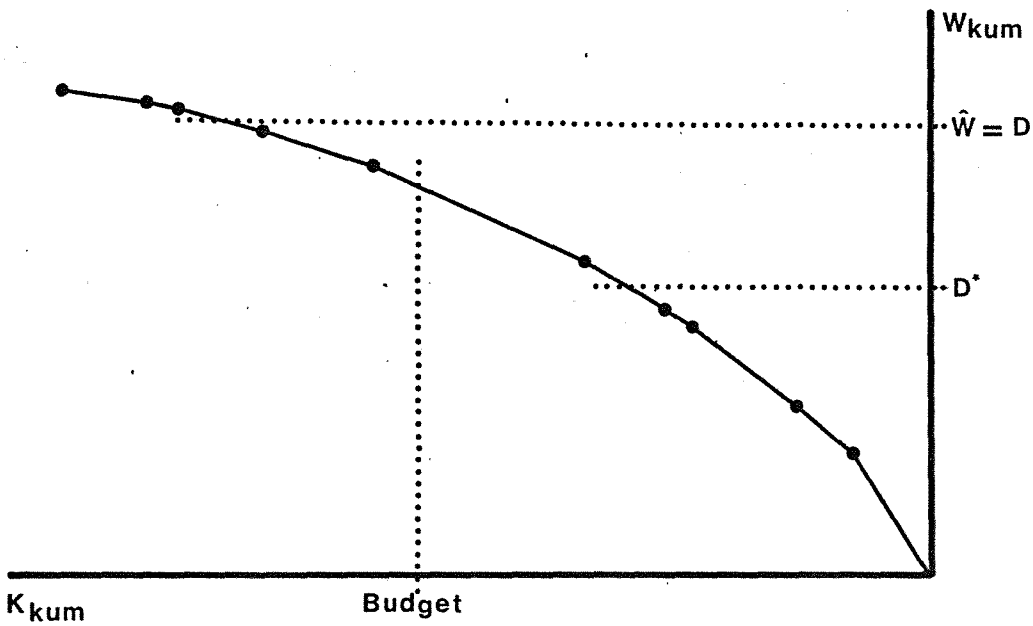


Fig.10b. Cumulative increase in welfare against cumulative costs.

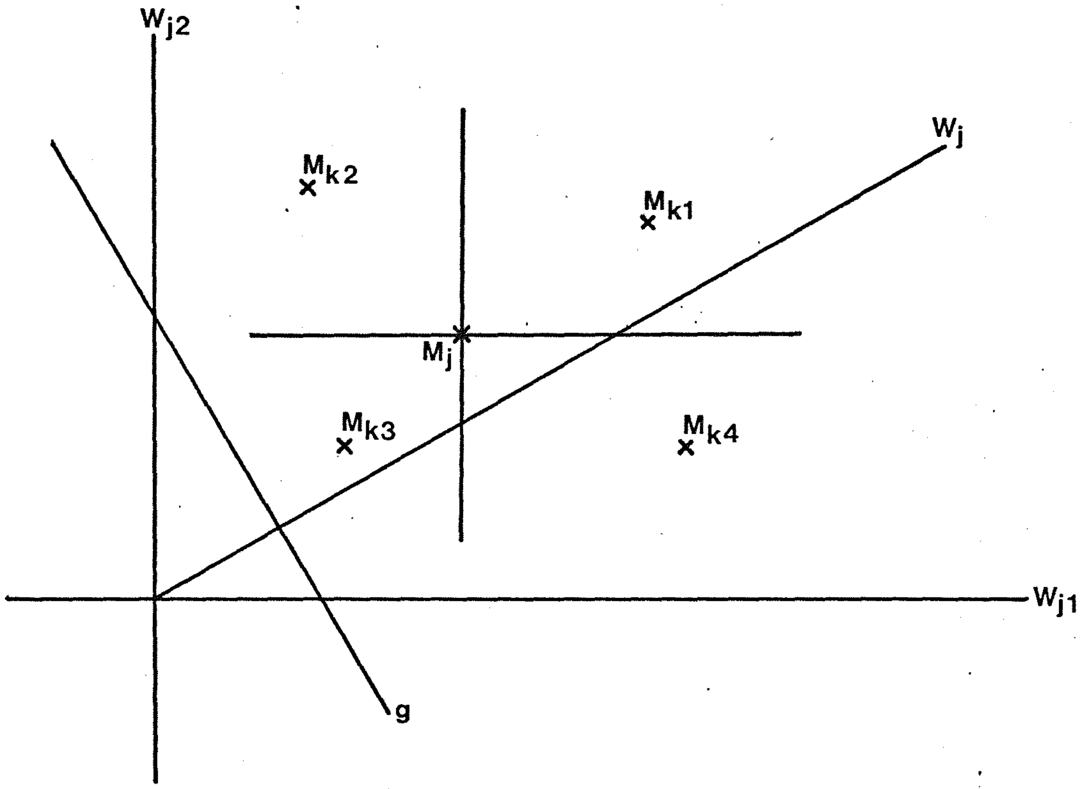


Fig.11. Rejection criteria for the case of multi_dimensional welfare effects.

	1	2	3	4	5	6
W_1	+	+	+	+	+	+
W_2	+	+	+	+	+	+
W_3	+	+	+	+	+	
W_4	+	+	+	+	+	
W_5	+	+	+	+	+	
K		+	+			
$N_d(Ps)$	130	125	130	118	42	140
$N_d(W)$	140	126	133	117	143	141
$N_d(K)$	-	40	43	-	-	1

N_d ( ): Number of measures judged by participant d

N_d (P_s): Number of measures with judgement of priority

N_d (W): Number of measures with judgement of welfare effect

N_d (K): Number of measures with judgement of costs

Table 1. Broad survey of data supplied by the participants