MORAL HAZARD PROBLEM SOLVING BY MEANS OF PREFERENCE RANKING METHODS

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Keywords: moral hazard, preference ranking, pseudo-model

Edited by: Matjaž Gams

Received: February 17, 1993 **Revised:** May 18, 1993 **Accepted:** July 21, 1993

Moral hazard problems in the field of humanitarian health aid delivery can be difficult to solve, especially in outstanding circumstances caused by human or natural factors. In this paper, we present a solution to this problem by means of preference-ranking methods. The idea of a pseudo-model is also included, where standard input is considered as well as subjective elements.

1 Presentation of the problem

The treatment of refugees from Bosnia-Herzegovina and Croatia in 1992 presents a problem which the Slovenian health care system has to solve on the macroeconomic level. The problems which occur are as follows:

- shortage of financial resources,
- shortage of sanitary and pharmaceutical material,
- daily variation of data which depends both on the domestic and foreign political environment.

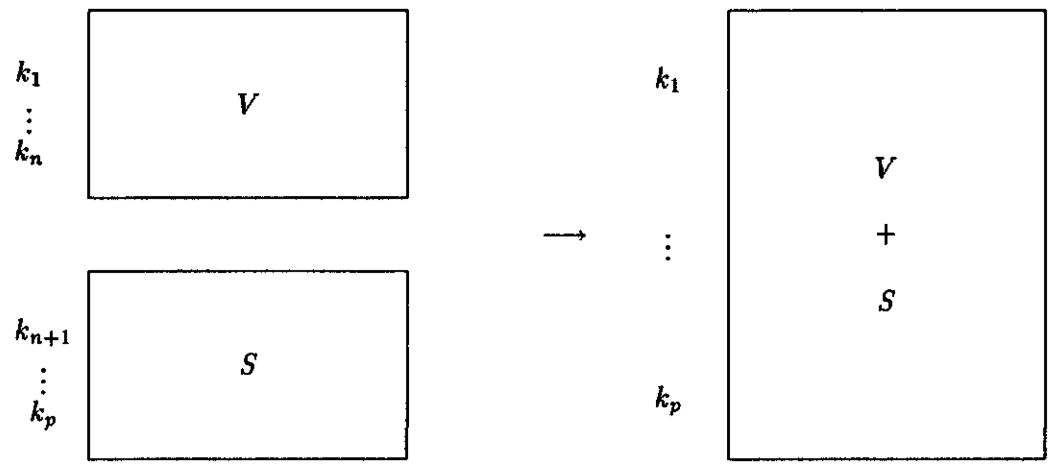
Since the media inform us daily about the lack of financial resources, we will not follow this topic any further. Let us address the issue of how much demand can be covered by the available state budget and how much help we can expect from various humanitarian organisations (domestic and foreign). Simultaneously, we raise the question, which risk group has priority at delivery. Therefore, our task is *moral hazard* problem solving.

With regard to available facilities of the Slovenian health care system (supply) and requests (demand), we defined criteria which can be considered in various optimization models, such as: rationalisation of sanitary material, medicines, maximisation of preventive medicine etc. This can be formalised as a vector of criteria $[k_1, \ldots, k_n]^T$. Along with standard criteria $k_1, \ldots, k_n$ they are the so-called subjective criteria, representing the impact on the final decision of subjective reasoning (see Figure 1) based on the estimated help from unreliable sources. The result of such a model is a set of optimal solutions of the preference functions under given conditions such that the space of optimal development of health aid is bounded by this optimal set.

Example. Suppose that we have two vaccination programmes for war refugees. The first one makes use of only reliable domestic resources, while the second one anticipates only financial and material support from abroad and charitable organisations. In the current situation, we can hardly judge which of the two programmes is more realistic.

2 Modern preference-ranking methods

The multicriteria nature of moral-hazard problems requires a suitable solving method. On the



V ...results from the optimisation and simulation model
S ...suitably formalised subjective elements

Figure 1: Combination of matrices V and S

basis of already-known advantages [3, 1] of up-to-date methods of multicriteria decision making, we decided to use the preference-ranking method as a tool for problem solving.

PROMETHEE (**P**reference **R**anking **O**rganization **Me**thod for Enrichment **E**valuations) is a group of general-purpose methods, developed in Europe and also used elsewhere in the world. Their purpose is to help the decision maker in alternative evaluations using preference functions. For detailed discussion of the methods, see [1], and [3] for a specialised version for health care system. Here we only devise the necessary theoretical basis for PROMETHEE.

Let A be the the set of feasible decisions (actions). Suppose that criteria $c_1, \ldots, c_m$ are applied by the decision maker to evaluate individual actions; in short, c_j are numeric functions defined on A. The decision maker defines a generalised criterion $Q_j(a,b)$, also called the *preference function* (PF) for every c_j. Actually, it is a function of the difference $c_j(a) - c_j(b)$, where $a, b \in A$. There are six standard types of PF [1] and three types specialised for health-care system problem-solving [3]. In addition, most types have some parameters to determine. The choice of type of PF will be shown later by an example.

Define *preference index* Π as the average of all generalised criteria:

$$\Pi(a,b) = \sum_{j=1}^{m} w_j Q_j(a,b),$$

where w_j are weights ($w_j \geq 0$, for all j and $\sum_{j=1}^{m} w_j = 1$), a and b are arbitrary actions. The basis for action ranking is given by the so-called *flows* (leaving, entering, and net flow):

$$\Phi^+(a) = \sum_{b \in A} \Pi(a,b),$$
$$\Phi^-(a) = \sum_{b \in A} \Pi(b,a),$$
$$\Phi(a) = \Phi^+(a) - \Phi^-(a).$$

Since the argument of PF is the difference $c_j(a) - c_j(b)$, the choice of parameters depends greatly on the distribution of differences for all $a, b \in A$. The use of PF is sensible only if the ranking can be influenced by their parameters. The accurate determination is left to the decision maker for the concrete problem. But the interval from the smallest to the biggest difference is recommended.

3 Formalisation of the pseudo-model

Given a situation where both standard and subjective elements are to be considered, we combine both matrices V and S into one matrix denoted by T (Figure 1). The entries of T represent the input into the PROMETHEE model. The procedure where the subjective elements are taken into account is called *pseudo-modelling*. In our case, by delivering health aid, the risk groups are ranked according to the results of pseudo-modelling.

Table 1: The model standard input

criteria	min/max	A_1 children	A_2 women	A_3 elder	A_4 rest	type p.f.	parameters
C_1	max	19.81	2.62	2.10	0.26	I	–
C_2	max	6.93	1.98	0.80	0.20	I	–
C_3	min	1.15	0.16	27.50	1.28	III	$p = 25$
C_4	min	96.25	27.50	11.00	2.75	III	$p = 65$
C_5	min	23.45	6.70	2.68	0.67	V	$p = 18, q = 0.60$

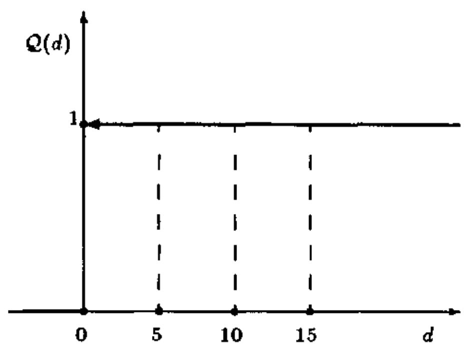


Figure 2: PF for criterion C_1

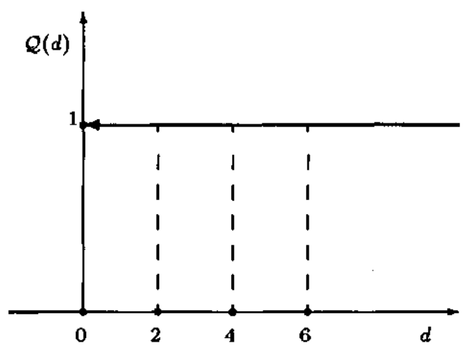


Figure 3: PF for criterion C_2

4 Numerical example

For preventive action, we take four health programmes (HP). The first one makes use only of reliable domestic resources, while the others foresee financial and material support from abroad and charitable organisations. Programmes differ in the costs which have to be covered for the same target i.e. the most suitable scheduling of risk groups versus different preventive programmes.

4.1 Under the first programme, all costs are covered by domestic resources (100%).

In table 1 only standard input is taken into account in the PROMETHEE model.

From table 1 it is clear that there are five criteria altogether which refer to the material costs of preventive vaccination. Criterion C_1 measures preventive examination costs, C_2 vaccination costs (labour, vaccine), C_3 sanitary material costs, C_4 laboratory material costs and C_5 medical costs. The first two are maximised on the 'better to prevent than to cure' principle, the other three are minimised.

The actions are represented as risk groups: children (A_1), women (A_2), elder persons (A_3) and others (A_4).

In table 1 the average values for each criterion and action are also shown.

The types of PF with adequate parameters are determined according to the rules in [1].

For the first criterion, we stick to the usual argument that high-quality preventive examination is particularly important, regardless of the costs. Accordingly, we choose the type of PF which treats every minimal difference d as strict preference. The type I suits these requirements and it has no parameters to determine (see Figure 2).

For the second criterion, we still do not rationalise the imunisation and vaccine costs. Both are necessary for preventing infections and deseases. Again, the most suitable choice is PF of type I. The difference between the costs of various immunisation programmes are illustrated in Figure 3.

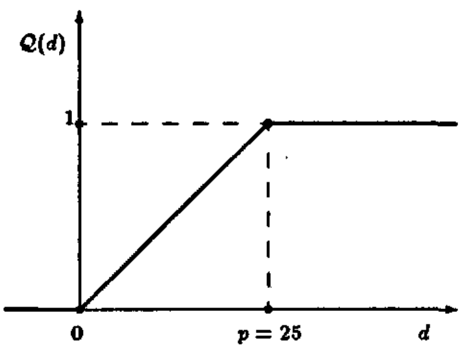


Figure 4: PF for criterion C_3

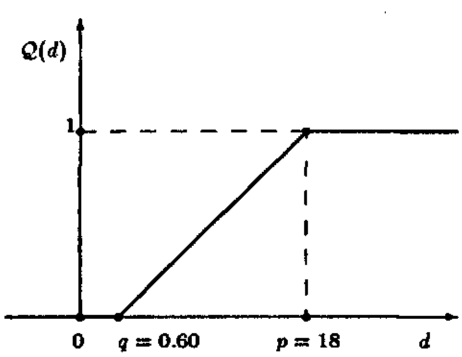


Figure 5: PF for criterion C_5

Criterion C_3 represents the costs of sanitary material, which are linearly dependent on its prices. The same is true for stored quantities. Here we choose PF of type III, i.e. PF with linear preferences. It is shown in Figure 4.

Type III of PF is also chosen for the fourth criterion and is justified by the same argument as for C_3.

For criterion C_5 the principle of rationalisation is used again. However, in contrast to the last two criteria, we introduce the so-called indifference threshold q. It stands for nonsensitivity to differences between costs of medicines to a certain extent. We pay attention to them only when the differences exceed the threshold. Such a situation can be dealt with using PF of type V with parameters q and p (Figure 5). The first parameter is the indifference threshold and the second denotes the strict preference threshold.

The results of the computer-solved problem are presented in Table 2.

The preference outranking list is defined by net flows. We see that the highest priority for delivering humanitarian aid has the risk group A_2 (women), followed by A_1 (children), A_4 (others) and A_3 (elder persons).

4.2 The second programme includes an additional two criteria O_1 and O_2, which determine implementability of C_1 and C_2 respectively, in the range between 91-100%. This means that domestic resources cover at least 90%, while the 1-9% gap will be covered in some other way. The second HP is considered to be optimistic because of the high rate of implementability.

Let us now combine the standard input data with the optimistic estimated implementability of criteria C_1 and C_2. Input data for this pseudo-model are shown in Table 3.

The results of analysis are presented in Table 4.

4.3 In the third HP, we are able to cover at most 75% of the costs, which determine the implementability of C_1 and C_2. In the model, two criteria of implementability are denoted by P_1 and P_2. This programme is considered pesimistic, in contrast with the previous one.

The data for standard input and the pessimistic HP are collected in Table 5.

The results of pseudo-modelling for the pessimistic cost coverage are presented in Table 6.

4.4 The last HP is a compromise between the previous two, because it is planned that 76-90% of the costs are covered by domestic resources. Here the criteria of implementability C_1 and C_2 are denoted by K_1 and K_2.

Table 7 containts the data which refer to the HP of compromise.

The results obtained are displayed in Table 8.

5 Comparison of the results

Since we considered

- the same standard input for all cases,
- the same types of PF for all cases,
- the same parameters for PF and
- the same weights for all criteria,

Table 2: Results of analysis at the standard input

action	leaving flow	enter. flow	net flow	outranking list
A_1	1.4010	1.1936	0.2075	2
A_2	1.4025	0.6286	0.7739	1
A_3	0.8901	1.4416	-0.5515	4
A_4	0.7802	1.2100	-0.4298	3

Table 3: Input data for the optimistic HP

criteria	min/max	A_1 children	A_2 women	A_3 elder	A_4 rest	tip p.f.	parameters
C_1	max	19.81	2.62	2.10	0.26	I	–
C_2	max	6.93	1.98	0.80	0.20	I	–
C_3	min	1.15	0.16	27.50	1.28	III	$p = 25$
C_4	min	96.25	27.50	11.00	2.75	III	$p = 65$
C_5	min	23.45	6.70	2.68	0.67	V	$p = 18, q = 0.60$
O_1	max	0.91	0.92	0.95	0.93	I	–
O_2	max	0.99	1.00	0.91	0.91	I	–

Table 4: Results of analysis of the optimistic HP

action	leaving flow	enter.flow	net flow	outranking list
A_1	1.2865	1.4240	-0.1375	2
A_2	1.5732	0.7347	0.8385	1
A_3	1.0643	1.3154	-0.2511	3
A_4	0.8430	1.2929	-0.4499	4

Table 5: Input data for the pesimistic HP

criteria	min/max	A_1 children	A_2 women	A_3 elder	A_4 rest	tip p.f.	parameters
C_1	max	19.81	2.62	2.10	0.26	I	–
C_2	max	6.93	1.98	0.80	0.20	I	–
C_3	min	1.15	0.16	27.50	1.28	III	$p = 25$
C_4	min	96.25	27.50	11.00	2.75	III	$p = 65$
C_5	min	23.45	6.70	2.68	0.67	V	$p = 18, q = 0.6$
P_1	max	0.60	0.70	0.65	0.67	I	–
P_2	max	0.62	0.63	0.68	0.74	I	–

Table 6: Results of analysis of the pesimistic HP

action	leaving flow	enter.flow	net flow	outranking list
A_1	1.0007	1.7097	-0.7089	4
A_2	1.5732	0.7347	0.8385	1
A_3	1.0643	1.4583	-0.3939	3
A_4	1.2715	1.0071	0.2644	2

Table 7: Input data for the HP of compromise

criteria	min/max	A_1 children	A_2 women	A_3 eldest	A_4 rest	tip p.f.	parameters
C_1	max	19.81	2.62	2.10	0.26	I	-
C_2	max	6.93	1.98	0.80	0.20	I	-
C_3	min	1.15	0.16	27.50	1.28	III	$p = 25$
C_4	min	96.25	27.50	11.00	2.75	III	$p = 65$
C_5	min	23.45	6.70	2.68	0.67	V	$p = 18, q = 0.6$
K_1	max	0.75	0.80	0.85	0.90	I	-
K_2	max	0.80	0.79	0.81	0.78	I	-

Table 8: Results of analysis for the HP of compromise

action	leaving flow	enter.flow	net flow	outranking list
A_1	1.2865	1.4240	-0.1375	3
A_2	1.2875	1.0205	0.2670	1
A_3	1.3501	1.1726	0.1775	2
A_4	0.9858	1.2929	-0.3070	4

Table 9: Net flow value analysis of the standard and optimistic HP

action	Φ_V	Φ_{V+S}	D	$\frac{D}{\lvert\Phi_V\rvert}(\%)$
A_1	0.2075	-0.1375	-0.3450	-166.27
A_2	0.7739	0.8385	0.0646	8.35
A_3	-0.5515	-0.2511	0.3004	54.47
A_4	-0.4298	-0.4499	-0.0201	-4.68

Table 10: Net flow value analysis of the standard and pessimistic HP

action	Φ_V	Φ_{V+S}	D	$\frac{D}{\lvert\Phi_V\rvert}(\%)$
A_1	0.2075	-0.7089	-0.9164	-441.64
A_2	0.7739	0.8385	0.0646	8.35
A_3	-0.5515	-0.3939	0.1576	28.58
A_4	-0.4298	0.2644	0.6942	161.52

the essential ascertaining is as follows. The addition of subjective elements to the standard input is the cause of change in the preference structure, i.e. the rankings of alternative risk groups. It can be deduced from the comparison of results that the smallest discrepancy is found between the standard and optimistic HP. The cause of this phenomenon lies in the high percentage of realisability of criteria C_1 and C_2. In the case where we decide to apply pseudo-modelling, moral-hazard problem solving depends on the input data of the subjective characters.

In the follow-up, we have to examine the changes of net flows which are due to the addition of subjective elements. Table 9 shows the values of net flows of the standard input Φ_V, as well as the optimistic programme Φ_{V+S}, the differences between net flows of the standard input $|\Phi_{V+S} - \Phi_V| = D$ for all actions, and changes relative to the net flows of the standard input ($\frac{D}{|\Phi_V|}$). The comparison of results between the standard and pessimistic HP is found in Table 10, while Table 11 refers to the standard programme and the programme of compromise.

The relative changes for particular actions are again minimal when comparing the standard and optimistic HP. Surely this is a consequence of the smallest discrepancy between the optimistic and standard HP in view of their inputs. In practical terms, with the optimistic HP the health-care system is able to cover almost all costs of health aid. In other words, with at most 9% reduction in certainty of the cost coverage, only two (already adjacent) actions swapped their places in the preference structure. Net flow analysis shows that their absolute values change with the addition of subjective elements and they do not change uniformly for each action. Therefore, the preference structure changes if:

Table 11: Net flow value analysis of the standard and HP of compromise

action	Φ_V	Φ_{V+S}	D	$\frac{D}{\lvert\Phi_V\rvert}(\%)$
A_1	0.2075	-0.1375	-0.3450	-166.27
A_2	0.7739	0.2670	-0.5069	-65.50
A_3	-0.5515	1.1770	1.7285	313.42
A_4	-0.4298	-0.3070	0.1228	28.57

– we add subjective elements and

– we change their values.

From this point the analysis can be continued, for instance with varying implementability intervals of criteria, and studying stability of preference structure. We can also consider more criteria of implementability. Finally, we can observe the behaviour of particular actions according to the varying implementability intervals of criteria or the addition of new criteria.

6 Summary

In this paper, we have exposed the moral-hazard problem in the field of humanitarian health aid delivery in outstanding circumstances. In the practical example, we have dealt with four various preventive health programmes. For the case when both objective and subjective elements are included, we constructed a pseudo-model. The PROMETHEE method is the basic tool for risk-group ranking. Both subjective and objective elements are treated equally, so we can avoid over and under estimation of either group of factors.

References

[1] Brans J.P., Mareschal B. (1986): How to select and how to rank projects. North Holland, European Journal of Operational Research (24), pages 228-238.

[2] Drummond Michael F., Stoddard Greg. L., Torrance George W. (1990): Methods for the Economic Evaluation of Health Care Programmes. Oxford, University Press, 182 pages.

[3] Saražin L. Ines, Grad Janez (1992): Multicriteria decision making in health care system (in slovene language). Ljubljana, Slovene economic review, (43/5), pages 334-347.