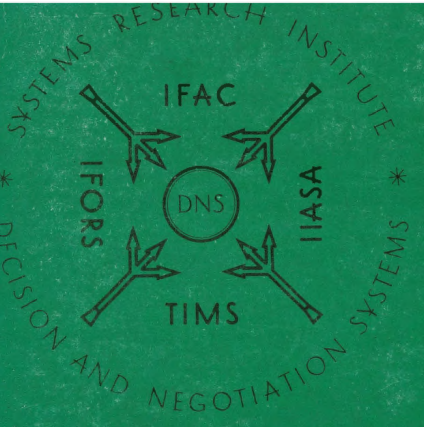

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SUPPORT SYSTEMS FOR DECISION AND NEGOTIATION PROCESSES

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Editors:

Roman Kulikowski
Zbigniew Nahorski
Jan W. Owsiński
Andrzej Straszak

Systems Research Institute
Polish Academy of Sciences
Warsaw, Poland

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Names of first authors: **L-Z**

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PAIRWISE COMPARISON OF CONCESSIONS IN NEGOTIATION PROCESSES

F.A. Lootsma, J.M. Sluijs, S.Y. Wang
Faculty of Technical Mathematics and Informatics
Delft University of Technology
Mekelweg 4, 2628 CD Delft, The Netherlands

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Abstract

Starting off with a pairwise-comparison method to evaluate the possible deals between two parties in conflict, we generalize the approach and we consider the case of three parties in conflict. The basic step is the subjective evaluation of a deal where each party offers exactly one concession. The trade-off of benefits and costs is judged in verbal terms which are subsequently converted into numerical values on a discrete geometric scale. Although the number of plausible geometric scales is large, the information to be used by a mediator appears to be scale-independent. The approach is illustrated by the results of an exploratory project aiming at a balanced CO_2 emission reduction in Poland, Brazil and the Netherlands. The success of the method depends largely on the information-processing support. Given the limitations of human imagination and human judgement, the method is not likely to be effective in a conflict between four or more parties although it can easily be generalized.

Key words

Negotiations, concessions, pairwise comparisons, trade-off estimates, cost-benefit ratios, verbal judgement, numerical scaling, CO_2 emissions.

1 Introduction

In an earlier paper, Lootsma (1989) presented a method to analyze a conflict between two parties, each being able to offer one or more concessions to the other in order to reduce the tension. The concessions cannot be made unilaterally but rather in mutual exchange. Thus, each party has to consider the subjective value of every possible deal, that is, each party has to estimate the subjective costs of its own concessions versus the subjective benefits of the concessions offered by the adversary. The evaluation is carried out via a

method of pairwise comparisons. Each party is supposed to have a representative who thoroughly knows the feelings of his rank and file. In the basic step of the evaluation procedure, a representative is requested to compare two concessions, one made by the adversary and one by his own party. Thus, taking $B_i > 0$ to denote the benefit of the adversary's i-th concession and $C_j > 0$ the cost of his own party's j-th concession, he is requested to estimate the trade-off B_i/C_j of the one-to-one deal (i;j). Let us take r_{ij} to denote the estimate. Even when the full matrix $R = \{r_{ij}\}$ is given, however, the benefits B_i and the costs C_j are not estimable. Moreover, there may be glaring inconsistencies in R, but the information can be used to calculate improved estimates t_{ij} of the respective trade-offs B_i/C_j via logarithmic regression. The full matrix $T = \{t_{ij}\}$ will enable the representative to identify possible inconsistencies in his judgement and to discuss the emerging pattern of acceptable (one-to-one or composite) deals with the members of his party. The two matrices of improved trade-off estimates, one for each party, can be handed over to a mediator who will possibly identify one or more deals which are acceptable to both parties.

This method would hardly be applicable if the representatives were supposed to estimate the trade-offs numerically. Therefore, each of them is requested to express the intensity of his feelings in verbal terms. Thus, believing that $B_i \simeq C_j$ he may declare himself to be indifferent between the two concessions; and he may have a weak, definite, strong, or very strong liking for the deal (i;j) accordingly as B_i exceeds C_j; similarly, he may have a weak, definite, strong, or very strong aversion for the deal $(i;j)$ accordingly as B_i is exceeded by C_j. These qualifications are converted into numerical values on a scale with geometric progression, thus providing the numerical estimates r_{ij}. Although the number of plausible geometric scales is large, the information to be used by the mediator appears to be scale-independent. It is worth repeating here that the benefits and the costs of the concessions are not really conceived in monetary terms. In a bitter conflict, concessions have emotional values which largely exceed their economic values.

The above method has been extended by Wang (1990) to analyze conflicts between n parties. However, in what follows we will concentrate on conflicts between three parties. This will not only simplify the notation. In an exploratory project, Sluijs (1991) discovered the limits of human imagination and human judgement: the method may be too complicated for $n \geq 4$, and in a conflict between three parties its success depends critically on the support given by the information-processing tools. In the basic step of the evaluation procedure, a representative is now requested to estimate the trade-off ratio B_{ij}/C_k, where B_{ij} stands for the benefit of the i-th and the j-th concession offered by the first and the second adversary respectively, and C_k for the cost of his own party's k-th concession. We take r_{ijk} to denote the numerical values of the verbal estimate, and t_{ijk} for the improved trade-off estimate calculated

via logarithmic regression in order to remove glaring inconsistencies from the original estimates r_{ijk}. The three matrices of improved estimates, one for each party, can be used by a mediator to identify the deals which are acceptable to all parties.

The organization of the paper is as follows. Section 2 describes the calculation of the improved trade-off estimates in the three-party case, as well as the numerical scaling of verbal judgement. Section 3 summarizes Sluijs' exploratory project, the balanced CO_2 reduction in three countries (Poland, Brazil, and The Netherlands) with widely varying economic conditions: the representatives of the respective parties were requested to evaluate the acceptability of joint policies (the deals) with particular CO_2 reduction targets in the respective countries. In section 4, the reader may find our final comments and conclusions.

2 Improved trade-off estimates

Let us consider the problem from the viewpoint of one of the representatives. For the time being, we suppose that he judged all possible trade-off ratios B_{ij}/C_k and that his verbal judgement has been converted into numerical values r_{ijk}. We estimate the trade-off ratio by the ratio $\hat{b}_{ij}/\hat{c}_j$, where $\hat{b}_{ij}$ and $\hat{c}_j$ denote components of a vector minimizing the sum of squares

$$\sum_i \sum_j \sum_k (\ell n\ r_{ijk} - \ell n\ b_{ij} + \ell n\ c_k)^2 . \tag{1}$$

Setting $\rho_{ijk} = \ell n\ r_{ijk}, \beta_{ij} = \ell n\ b_{ij}$, and $\gamma_k = \ell n\ c_k$, the problem reduces to the least squares problem of minimizing

$$\sum_i \sum_j \sum_k (\rho_{ijk} - \beta_{ij} + \gamma_k)^2 . \tag{2}$$

A solution with components $\hat{\beta}_{ij}$ and $\hat{\gamma}_k$ is not unique (see Scheffé (1959)), but the so-called contrasts $\hat{\beta}_{ij} - \hat{\gamma}_k$ are uniquely determined. They can be solved from the associated, linear system of normal equations, explicitly if all possible trade-off ratios have been estimated, and implicitly if some of these ratios have been left out of consideration. The improved trade-off estimates

$$t_{ijk} = \exp\left(\hat{\beta}_{ij} - \hat{\gamma}_k\right) = \hat{b}_{ij}/\hat{c}_k$$

provide a collection of smoothed numerical values to estimate the subjective trade-off ratios B_{ij}/C_k.

In the basic step of the estimation procedure, the representative is requested to express the intensity of his feelings for the deal where the i-th and the j-th concession of his respective adversaries are offered in exchange for his k-th

concession. Thus, he may choose one of the following gradations of comparative judgement:

yes !!	very strong liking
yes !	strong liking
yes	weak liking
indifference	
no	weak aversion
no !	strong aversion
no !!	very strong aversion.

We associate these gradations with echelons $e_k, -3 \leq k \leq 3$, on a numerical scale in the following manner:

yes !!	e_3
yes !	e_2
yes	e_1
indifference	$e_0 = 1$
no	e_{-1}
no !	e_{-2}
no !!	e_{-3}.

On the assumption that subsequent intensities of feelings constitute a sequence with geometric progression (such a phenomenon is well-known in psychophysics), we write

$$e_k = \exp(\lambda k),$$

where λ represents the unknown scale parameter. The conversion of verbal judgement into numerical values can now be expressed by

$$r_{ijk} = \exp(\lambda \delta_{ijk}),$$

where the index δ_{ijk} is an integer, $-3 \leq \delta_{ijk} \leq 3$, designating the gradation which has been chosen by the representative to estimate B_{ij}/C_k.

Since the mediator only has to identify deals which might be acceptable to all parties (see Lootsma (1989), Wang (1990)), it is not necessary to find an appropriate value for λ. On the basis of our experiences in multi-criteria analysis, however, we could recommend the value $\lambda = \ell n\ 4 = 1.4$, implying that the echelons associated with the gradations of comparative judgement constitute a geometric sequence with progression factor 4.

The method can be generalized even further: each party may have several representatives, and they may have different opinions. Taking r_{ijka} to stand for the numerical value assigned to representative (actor) a's estimate of B_{ij}/C_k, we are confronted with the least-squares problem of minimizing

$$\sum_i \sum_j \sum_k \sum_a (\ell n\ r_{ijka} - \ell n\ b_{ij} + \ell n\ c_k)^2, \qquad (3)$$

where the summation over the index a runs over the set of representatives (actors) who actually expressed their opinion about the i-th, the j-th, and the k-th concession offered by the respective parties. The normal equations will again be linear so that we can easily obtain improved trade-off estimates.

3 Balanced CO_2 emission reductions

Within the framework of international attempts to control the global warming (worldwide measures against the so-called greenhouse effect are now under consideration in political circles), Sluijs (1991) explored the potential of the method just sketched in order to assess the acceptability of multi-lateral deals for the reduction of CO_2 emissions. Representatives of the following countries were involved in the experiment:

The Netherlands: A rich country with a highly developed industrial sector and a high income per capita. The energy system is mainly gas-oriented.

Poland: A country in economic transition and with an obsolete industrial sector. The income per capita is much lower than in the Netherlands.

Brazil: A country with huge financial problems and a relatively small industrial sector. Furthermore, it is characterized by a relatively low income per capita. The Brazilian CO_2 emissions are mainly caused by deforestation.

In each of these countries, the population may accept CO_2 reduction measures. This depends on the perception of the global warming problem and on the efforts made by other countries. Without such measures, in a business-as-usual scenario, the CO_2 emissions of the Netherlands, Poland, and Brazil in the target year 2030 would exceed their respective 1991 emissions by 63%, 96%, and 59% (current studies by the International Panel on Climatic Change established by the United Nations). We suppose that each of the three countries has six possible reduction strategies, each leading to CO_2 emissions in 2030 deviating from the actual 1991 emissions by 40%, 20%, 0%, -15%, -30%, and -50%. In what follows, we shall refer to these percentages as the emission targets or the concessions.

A possible deal between the three countries is a triple of emission targets, one for each country. In principle, there are $6^3 = 216$ possible deals, but since it is unrealistic to ask the representatives to judge all of them, the amount of work had to be reduced. Figure 1 shows a set of questions, a so-called case, submitted to a Brazilian representative; given the concessions of the Netherlands (a reduction by 30% in the target year) and Poland (stabilization at the actual 1991 emission level), he was requested to judge their "benefits" with respect to the "costs" of the six possible concessions of his own country.

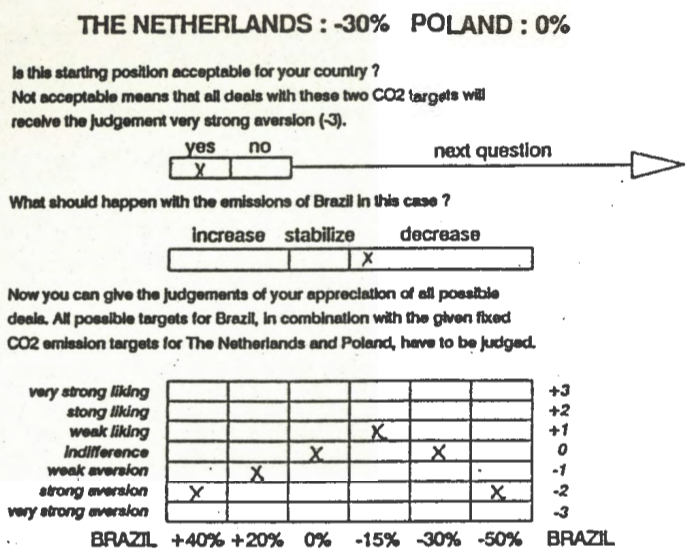

Figure 1. Set of questions (a case) submitted to a Brazilian representative. Starting from certain concessions by the Netherlands and Poland, he is requested to estimate the benefit-cost ratio of six concessions offered by his own country.

	EMISSION TARGETS NL	PLN	BRZ	ESTIMATION OF THE DUTCH ACCEPTATION
nr. 1	(-50%	-15%	+40%)	-0.1
nr. 2	(-50%	-50%	-15%)	-0.1
nr. 3	(-50%	-50%	+40%)	-0.3
nr. 4	(-50%	-15%	-15%)	-0.4
nr. 5	(-50%	-15%	+20%)	-0.4
nr. 6	(-15%	-50%	-15%)	-0.4
nr. 7	(-50%	0%	+40%)	-0.5
nr. 8	(-15%	-15%	+40%)	-0.5
nr. 9	(-30%	-50%	-15%)	-0.6
nr.10	(-30%	-15%	+40%)	-0.6

Table 1. The top-10 deals of the three Dutch representatives. Since the logarithms of the improved trade-off estimates are all negative, none of the deals is really acceptable: the estimated benefit-cost ratios are smaller than 1.

In total, he had to consider 18 such cases in order to evaluate his country's position. Eventually, there were three representatives for the Netherlands, six for Poland, and one for Brazil in the experiment.

When the improved trade-off estimates are used to stand for the acceptability of the deals, the Tables 1, 2, and 3 show the top-10 deals of the Dutch, the Polish, and the Brazilian representatives. The last column in each of these tables contains the acceptability in the form of a logarithm: the number-one deal (-50%, -15%, +40%) of the Dutch representatives, for instance, has the improved trade-off estimate $\exp(-0.1\lambda)$, etc. In Table 4 the reader will find the top-10 deals on the basis of the smallest of the three acceptabilities (a maximin criterion). Table 5 displays the top-10 deals ranked on the basis of the product of the three improved trade-off estimates.

4 Discussion of the results

The representatives of all three countries had a strong aversion against the deal (+40%, + 40%, + 40%) with the worst possible emission targets in 2030. Thus, the global warming problem is considered to be a serious one. The representatives clearly thought that a global CO_2 reduction would be necessary. The key question is how to distribute the burden of the reduction strategies. According to their representatives, the three countries take the following position.

From the Dutch viewpoint, none of the proposed deals is really acceptable. Even the number-one deal is just rejected. The general tendency is that Poland and the Netherlands should accept significant CO_2 emission reductions, while Brazil is allowed to increase its annual CO_2 emission.

The Polish representatives accept significant CO_2 emission reductions only if both Brazil and the Netherlands accept targets of the same order of magnitude (-30% or -50%).

The Brazilian representative may accept a stabilization or a slight reduction of the CO_2 emissions (0% or -15%) only if Poland and the Netherlands accept significant reductions (-30% or -50%).

The complexity of the global warming problem makes it hard for the countries to form a consistent opinion on the acceptability of the proposed deals. Moreover, it seems to be impossible to estimate the economic effects of the reduction strategies. Thus, we could only fathom the willingness of the countries to accept non-trivial measures on the speculative ground that these are required to protect the environment. The top-10 deals indicate where an international consensus may be found.

We conclude this paper with a few remarks on the methodological issues. Pairwise comparison of concessions in a negotiation process may help the conflicting

	EMISSION TARGETS NL	PLN	BRZ	ESTIMATION OF THE POLISH ACCEPTATION
nr. 1	(-30%	-15%	-50%)	2.0
nr. 2	(-30%	0%	-50%)	1.7
nr. 3	(-50%	-15%	-50%)	1.5
nr. 4	(-30%	-15%	-30%)	1.5
nr. 5	(-50%	-15%	-30%)	1.3
nr. 6	(-30%	-50%	-50%)	1.2
nr. 7	(-30%	-15%	0%)	1.2
nr. 8	(-50%	0%	-50%)	1.1
nr. 9	(-30%	-30%	-50%)	1.1
nr.10	(-30%	0%	-30%)	1.1

Table 2. The top-10 deals of the six Polish representatives. Since the logarithms of the improved trade-off estimates are all positive, these deals are in principle acceptable: the estimated benefit-cost ratios are greater than 1.

	EMISSION TARGETS NL	PLN	BRZ	ESTIMATION OF THE BRAZILIAN ACCEPTATION
nr. 1	(-30%	-30%	+20%)	2.3
nr. 2	(-30%	-30%	0%)	2.1
nr. 3	(-30%	-30%	-15%)	1.9
nr. 4	(-30%	-30%	-30%)	1.1
nr. 5	(-50%	-50%	+20%)	1.0
nr. 6	(-50%	-50%	0%)	0.9
nr. 7	(-50%	+30%	+20%)	0.9
nr. 8	(-50%	+30%	0%)	0.8
nr. 9	(-30%	-50%	+20%)	0.8
nr.10	(-30%	-50%	0%)	0.7

Table 3. The top-10 deals of the Brazilian representative. Since the logarithms of the improved trade-off estimates are all positive, these deals are in principle acceptable.

	EMISSION TARGETS			ESTIMATION OF THE ACCEPTATION IN		
	NL	PLN	BRZ	NL	PLN	BRZ
no. 1	(-30%	-50%	-15%)	-0.6	-0.1	0.4
no. 2	(-50%	-30%	0%)	-0.7	-0.3	0.5
no. 3	(-50%	-50%	-15%)	-0.1	-0.9	0.6
no. 4	(-30%	-15%	-15%)	-0.9	0.7	-0.3
no. 5	(-50%	-50%	0%)	-1.0	-0.2	0.9
no. 6	(-30%	-30%	0%)	-1.1	0.3	2.1
no. 7	(-50%	-50%	-50%)	-1.2	0.7	-0.7
no. 8	(-50%	-50%	-30%)	-1.2	0.5	-0.2
no. 9	(-50%	-15%	0%)	-0.9	0.6	-1.3
no.10	(-30%	-50%	0%)	-1.4	0.4	0.7

Table 4. The top-10 deals ranked according to the smallest of the three acceptabilities (the logarithms of the improved trade-off estimates).

	EMISSION TARGETS			ESTIMATION OF THE ACCEPTATION IN		
	NL	PLN	BRZ	NL	PLN	BRZ
no. 1	(-30%	-30%	0%)	-1.1	0.3	2.1
no. 2	(-30%	-15%	0%)	-1.4	1.2	-0.1
no. 3	(-30%	-50%	0%)	-1.4	0.4	0.7
no. 4	(-30%	-50%	-15%)	-0.6	-0.1	0.4
no. 5	(-50%	-50%	0%)	-1.0	-0.2	0.9
no. 6	(-30%	-30%	+20%)	-1.4	-1.2	2.3
no. 7	(-50%	-50%	-15%)	-0.1	-0.9	0.6
no. 8	(-50%	-30%	0%)	-0.7	-0.3	0.5
no. 9	(-30%	-15%	-15%)	-0.9	0.7	-0.3
no.10	(-30%	-30%	-50%)	-2.5	1.1	0.5

Table 5. The top-10 deals ranked according to the product of the three acceptabilities (the sum of the logarithms of the improved trade-off estimates).

parties to find the acceptable deals and to identify the inconsistencies in their judgements. Often, a mediator plays an important role in negotiations. The procedures in Lootsma (1989) and Wang (1990) could efficiently be applied to resolve some conflicts, especially some negotiation problems, because they confront the representatives with the consequences of their choices in a rational and logical manner. However, since human beings do not easily follow the results of a mathematical analysis, and because their behaviour becomes even worse in hard negotiation processes, we expect that only slow progress can be made, even when the analysis is repeatedly applied. Another feature of our approach is that the benefits and the costs of the concessions are not really conceived here in monetary terms. In a bitter conflict, concessions have symbolic or emotional values which largely exceed their economic values. We are concerned here with the concessions as perceived by the parties within the framework of an actual conflict.

Trade-off analysis should be applied with a maximum of flexibility and imagination. The representative of a party, for instance, could ask his members to estimate all concessions from the viewpoints of the other parties, thereby forcing them to perceive the conflict through the eyes of the adversaries.

At last, the approach is not likely to be effective in a conflict between four or more parties because of the limitations of human imagination and human judgement which were discovered by Sluijs (1991).

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