Model of Dynamic Multicriterial Evaluation and Selection - MODES

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Abstract: *The choice of the most favourable development scenario is, in essence, reduced to the problem of multicriteria decision making. Several examples of the most favourable scenario choice show that the choice is usually based upon mostly qualitative or extremely subjective criteria. If these quantitatively expressed criteria are used, then, as a rule, the final result of such a scenario, measured at the end of a simulation period, or expressed as an average criteria for the whole simulated period, produces a thoroughly static character for that choice. The basic idea of this paper is that the choice of the most favourable development scenario should be made based on combined quantitative and qualitative criteria in such a way that current (at every point in time of a simulated future development), dynamic (throughout the simulated future development period of time), and cumulative (in a total simulated period of time) efficiency of a certain version or a certain scenario is taken into account. This is an attempt to ensure that a dynamic component is included in the process of evaluating and choosing the most favourable scenario of a future development of a modelled system. Therefore, application of MODES creates the basis for an additional analysis and a comparison of individual scenarios.*

1. Problem formulation

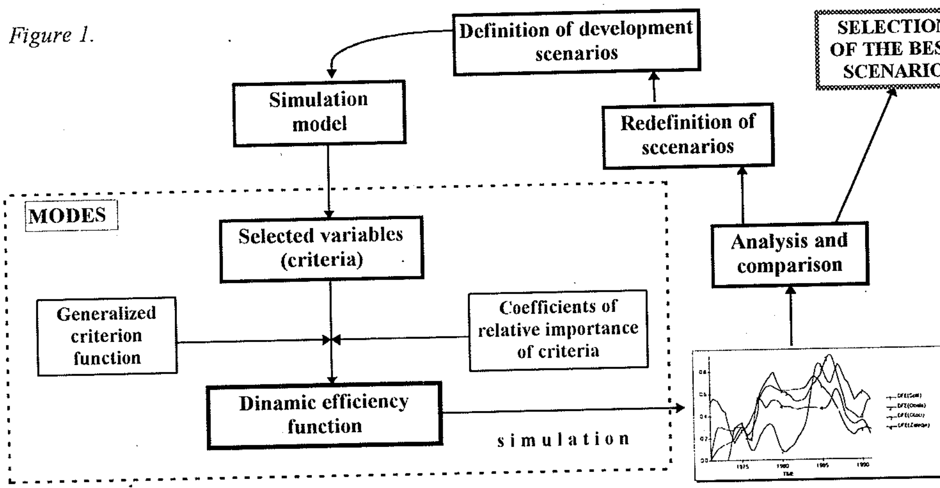
Designing different scenarios for the future dynamic development of a social-economic system is an extremely difficult and demanding task, to be entrusted to experts or those well acquainted with the system. Different variants or scenarios are the result of different forecasts and assumptions related to the future movement of a number of significant variables, controlled or non-controlled, which determine the dynamic behaviour of the real system. The final goal is identification and then selection of such a scenario which can provide an optimal balance of possibilities and wishes in terms of meeting previously specified development goals, considering the fact that it is not possible to meet all the requirements, which requires the determination of adequate priorities.

In some of the earlier examples of selection of the best scenario qualitative and quantitative approaches were used, and sometimes combined. However, preferring the latter, quantitative-model approach to support the global management process, in this work we shall point out the weakness of the results achieved by the quantitative-simulation model at the stage of multi-criteria evaluation. Namely, the examples of selected exogenous and endogenous model variables used as criteria in scenario selection show that the simulation results of these variables are used partially, i.e. most frequently only those quantities which express the final effect of a scenario - the effect referring to the end of the simulated period, or those quantities which express the average value of criteria for the entire simulated period. In this way the selection has a static character. Besides, the possibilities of a thorough analysis of the expected effects are severely limited. Since all these development scenarios are medium-term and long-term ones, we think that it is of great importance to analyse and compare the effects of individual scenarios at each point of time during the simulated period, starting from the assumption that different all scenarios are not equally suitable for the beginning, the middle, or the end of the total simulated period; so one has to take this into account when selecting the best scenario. In other words, it is necessary to include the dynamic component in the process of evaluation and selection of the best scenario, which would provide the evaluation of the current (at each point of time), dynamic (continuously throughout the simulated period), and eventually of the cumulative efficiency (in the total simulated period) of a particular scenario. Finally, the question of methodology which can include the dynamic component into the procedure is raised. This paper will propose a possible approach, greatly utilising the advantages of model support to the management process, the advantages of computer simulation of development scenarios, and especially the advantages of the system-dynamic simulation methodology.

2. Model of dynamic multicriterial evaluation and selection (MODES)

Design of MODES is based on all the known achievements of the multi-criteria decision-making methods, and it includes all the characteristic stages i.e. procedures with the same or altered content. Figure 1. shows the global procedure of design and use of the model.

Figure 1.



Selection of criteria (*Ki*): Inputs and outputs of the simulation model are assumed or generated series of values of different exogenous and endogenous variables in the chosen simulation period, which to a greater or lesser extent determine the future development of the system modelled. Therefore, when we reach the stage of evaluation and selection, the mentioned exogenous and endogenous variables will become *criteria (Ki)* for that evaluation and selection.

Selection of preference function (P_{ki}): Our intention is to use the well known achievements of different methods of multi-criterial decision-making, so in this case, i.e. when selecting the preference function we shall use the *'generalised criteria functions'* from the PROMETHEE method [*Brans and Vincke, 1985*] allowing some corrections in accordance with nature of the criteria chosen.

Coefficients of the relative importance of criteria (Wi): As all criteria do not have the same relative importance, when evaluating efficiency of a particular scenario, they have to be given appropriate weights. The technical condition here requires that sum of all weights equals to one.

2.1. Defining the dynamic function of efficiency

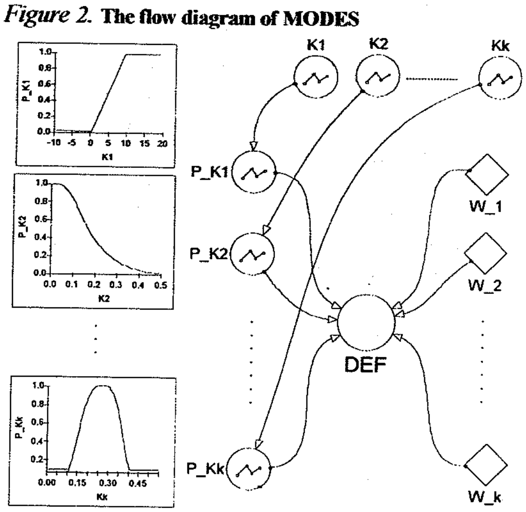
If we mark the particular development scenario with S_j, the value of criterion K_i in scenario S_j will be defined as V_{ij}. However, when selecting the optimal development scenario according to the simulation results, where each scenario is simulated on the corresponding model of the real system, the value of criterion V_{ij} *is dynamised*, i.e. one criterion value is substituted by a series of values $V_{ij}(t)$, t=1,2,3,...,N, where N is the length of simulation period, or the time horizon of the scenario. By dynamising the criterion value $V_{ij}(t)$, the value of preference function *is also dynamised* for the corresponding criterion value - P_{Ki} $[V_{ij}(t)]$, which means that now the preferences of scenario S_j are changed according to criterion K_i at each point of the simulated period. If the same approach is applied to all the criteria used in evaluation and selection of the optimal scenario, the final result will be the dynamisation of the total preference function of the corresponding scenario, which shall be called *'dynamic efficiency function'* of the scenario S_j - $DEF_j(t)$. Therefore, the formula defining the 'dynamic efficiency function' of the scenario S_j is:

$$DEF_j\ (t) = \Sigma\ P_{Ki}\ [V_{ij}(t)] \cdot W_i$$

2.2. *Integration of MODES into the real system simulation model*

Considering the starting hypothesis on the complementarity of MODES with the quantitative-model or simulation approach to testing of potential effects of the scenarios defined, where the outputs of the simulation model are used as criteria for evaluation and selection, it is logical to integrate the MODES into the structure of simulation model. In that way we can not only ensure fast and efficient testing of particular scenario effects, but we can also provide the possibility of effective multi-criterial analysis and comparison of these scenarios. For that purpose, we have used the exceptional advantages of the system-dynamic simulation methodology and simulation program language POWERSIM. The flow diagram of MODES is:

Figure 2. **The flow diagram of MODES**



On the top of the flow diagram there are the chosen variables, i.e. criteria which are the direct output of the simulation model. On the left there are preference functions defined for each of the *k* criteria, which in POWERSIM-notation can be represented by GRAPH - function as follows:

aux P_K1 = GRAPH (K1, -10, 2, (0,0,0,0,0,0,0.2, 0.4, 0.6,0.8, 1,1,1,1,1,1))
aux P_K2 = GRAPH (N, 0, 0.05, 1,1,0.96,0.85, 0.63,0.37,0.16,0.07,0.02,0,0,0,0,0)),
and so on.

On the right there are importance coefficients for each of the criteria, which in POWERSIM-notation are defined as constants:

const W_K1 =
const W_K2 =
....
const W_ Kk =

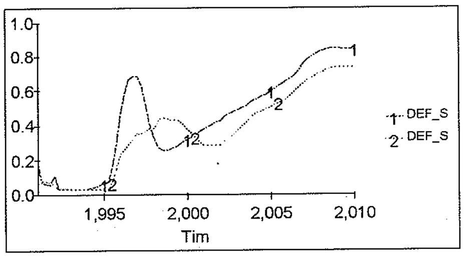
Finally, the 'dynamic efficiency function' (DEF), as the basic structural component of the flow diagram in POWERSIM-notation will be:

aux DEF = P_K1*W_K1 + P_K2*W_K2 + ... + P_Kk*W_Kk

3. Simulation, analysis, and comparison of development scenarios based on the MODES

The process of simulation, analysis, and comparison of different development scenarios requires previous formulation of scenarios (S_j). By simulating the mentioned scenarios for the future development of the modelled social-economic system, the previously defined 'dynamic efficiency function' will result in a corresponding *'efficiency curve'* for each of the scenarios (see Figure 3).

Figure 3. **Efficiency curves of the chosen scenarios**



By comparing the efficiency curves it is easy to conclude that a particular scenario variant is not equally favourable within the characteristic sub-periods of the simulation time horizon, and that in terms of evaluated efficiency the chosen variants are not equally interrelated during the simulated period.

4. Conclusion

Summarising the basic characteristics of the MODES points out the following:

a) The 'efficiency curves' generated by the MODES provide the evaluation of efficiency of a particular scenario, as well as the comparison of efficiency of different scenarios at every moment of the simulated future period. In that way the simplified, static approach to scenario selection is avoided. This provides the basis for a complete analysis of scenario efficiency during the sub-periods of the total simulated period. The results of such analysis can be used not only for evaluation and selection of the 'best scenario', but also for combining positive characteristics of the existing scenarios with thepurpose of determining a new and even a better scenario for the whole simulated period.

b) Direct integration of the MODES into the structure of the simulation model affirms the advantages of computer-simulation model support in managing the complex social-economic systems. In this way conditions are created for a fast and efficient testing of change effects in any of the controllable or non-controllable variable within the simulation model structure.

c) Integration of the MODES into the structure of computer simulation model provides also a fast and efficient testing of change in any component of the MODES on the preference of the corresponding scenario.

References:

[1] J.P. Brans and P.H. Vincke, *A preference ranking organisation method - The PROMETHEUS Method for Multiple Criteria Decision-Making,* Management science, Vol. 31, No 6, 1985

[2] B. Grcic, *Simulation Model of the Management by Regional Development,* Ph.D. Thesis, Economic Faculty Split, 1996., Croatia

[3] B. Grcic, Z. Babic, E. Jurun, N. Plazibat-Tomic, *Multicriterial analysis of development scenarios*, Proceedings of the 7th International Conference of Information Systems -IS '96, Varazdin, 1996., Croatia

[4] A. Munitic, *Computer Simulation with Help of System dynamics,* in Croatian, science practical book, Editor: BIS Split, pages 297, 1989, Croatia