Multicriterion Analysis Aided Project Rankings under Payoutflows Homogenization Constraint

in Transport Infrastructural Investment

by

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ABSTRACT - Consider: 1) a finite set of transport infrastructural investment projects (TIIP) previously analyzed by the decision maker(s) in the framework of some multicriterion analysis process in order to reveal a preference (i.e. precedence) - relation pair set (PRS) and; 2) the ranking problem of this TIIP subject to the PRS constraints and a quasi-equal financial expenses' rhythm - constraint. We outline an algorithmic aid of this ranking problem exploiting deliberately the non-mutual congruity between an incomplete PRS and resulting hierarchical structures.

KEY WORDS: hierarchical decomposition, non-mutual congruity, multiplicity, compromise hierarchical structures, transport infrastructural investments, decision support system.

INTRODUCTION

In countries with economies in transition, like quasi totality of Central and Eastern European countries, for evident reason, the infrastructural development of transportation is presently one of the most important preoccupations. Government authorities, in collaboration with professional institutions, different academic, political and civil organizations must first define basic needs and constraints at the regional, national and continental levels so as to arrive at a list of economically viable projects.

First of all, the transport infrastructural projects must be identified, i.e. those with a potential to increase the well-being, undergo the classic feasibility/effectiveness analysis (cf. for example Berg [8], Monigl et al.[6] and Simons [5]). Next, a preliminary ranking is done under a more or less large cardinal set of relevant criteria. This latter step accounts for direct and indirect effects (Roy and Hassan [2]) and other constraints, such as nvironmental impacts, traffic engineering, security, legal requirements (Kiss and Tanczos [1]), within the framework of multiple criteria decision process.

In this paper we will deal with an extension of multiple criteria decision aid by considering the ranking problem of a finite set of transport infrastructural investment projects (TIIP) subject to a preference (i.e. precedence) - relation pair set (PRS) generated within the framework of multicriterion analysis process and a quasi-equal financial expenses' rhythm-constraint. Following a descriptive presentation of decision problem, where we outline particularities most pertinent aggregated criteria and a list of real transport infrastructural investment projects, we briefly discuss fundamental elements of multicriterion analysis. In the algorithmic design section, after having presented algorithmic-functional relations between a multicriterion analysis process generated (afterwards eventually user updated) PRS and an ordered multi-part graph, we give a formal description of algorithmic approaches to obtain a compromise hierarchical structure simultaneously satisfying the PRS constraints and the quasi-equal financial expenses' rhythm-constraint. Then a didactical example section which presents a real ranking problem and finally, we conclude our paper with a few remarks and further considerations.

DECISION PROBLEM DESIGN

The types of transport infrastructures to be considered take into account all transportation modes. Airports, harbors (including waterways) have always been the focus of the private sector, hence there is no shortage of techniques involving private sector funds for financing such projects. However, the majority of the railway infrastructure projects in Europe have been developed using mainly public sector funds. With the beginning of the railways'privatization, the private sector must assume a greater share. Thus more and more, roads, bridges, tunnels and different elements of the urban transport systems are falling within the purview of the private sector. As more and more projects are being funded from the same finite source, they must be ranked. Therefore, the decision problem consists essentially of a ranking and a resource allocating problem.

SYNOPSIS OF CRITERIA

Taking into account the special caracteristics of major transport investment projects like the locational fixity, overcapacity, magnitude of risk and uncertainty etc., a coherent set of criteria must contain at least the following aggregated attributes:

-social impact,
-traffic impact,
-economic impact,
-financing considerations,
-technical impact,
-environmental impact,
-security/safety.

- Social impact

Transport always gives rise to effects which are not limited to the transport sector itself. The transport infrastructure is an important factor in the spatial development of cities, regions and countries. The attractiveness of the location of economic activities depends, among other things, on their relative accessibility, as well as the quality and the volume.The regional development issue is going to be a factor of critical importance in Central and Eastern Europe. A significant portion of investment in transport infrastructure goes to backward regions so as to bring out whatever competitive advantages these regions might have *vis-à-vis* the rest of Europe, for, as is well-known, newly developed links in transport networks result in a significant increase in the potential productivity of a region or nation.Improvement of transport infrastructure influences both production and household consumption. It leads to reduction in transport cost and in travel times. This may give rise to substantial redistribution effects among economic groups of society and also among regions.The social impact, taking into account all the factors mentioned above, is a criterion to be *maximized*. It reflects an integrated analysis of productivity and location effects of transport infrastructure and is *measured* on a *cardinal scale*.

- Traffic impact

The land use changes influenced by the transport infrastructural development affect levels of traffic demand, in terms of trip generation. That increased demand requires the provision of greater transportation capacity, which can influence further changes in land use. The interaction between land use changes (either in terms of new or replacement uses) requires continuous traffic impact analysis. The techniques covered by these technologies enable the analyst to determine how well a future transport network or system of facilities will serve a proposed change in land use.Because traffic impact analyses are always site specific, they have to be very detailed and they vary considerably in content. Some are basic, that is they apply to the development or redevelopment of small sites which have a limited propensity to generate traffic and therefore a limited impact on the transportation network. Others are complex, in that they concern large traffic generators or extremely complex traffic conditions. Traffic impact analysis is therefore carried out to permit the following:determination of the travel demand and traffic generated by the proposed development;identification of deficiencies in the proposed transportation systems;identification of improvements necessary to maintain acceptable levels of service.The total estimated traffic (taking into account the peak hour situation) is obtained by combining the elements of passenger and freight transport. This criterion is to be *maximized* and is *measured* on a *cardinal scale*.

- Economic impact

The governments and the local authorities have comprehensive co-ordinating responsibilities for the development of transport infrastructure. Market forces are important too because the transport infrastructure services belong to that category of publicly provided services, which are more or less fully charged for.Optimal pricing principles of the transport services run by public agencies have to be determined. In terms of the total cost of transport, infrastructure comes third or fourth in importance compared with the other principal cost factors. Cnsiderably greater are the user time costs in the case of passenger transport and the capital and operating cost of the transport vehicles. The fact that the transport infrastructure owner's total costs constitute a relatively small part of the total system cost is the rule in the transport sector, hence the environmental costs have to be taken into account with a separate criterion. In order to maximize the economic impact, governments and local authorities must strive to minimize applicable costs. Therefore, total costs are to be *minimized* and are *measured* on a *cardinal scale*.

- Financing considerations

Of course, in a private - public sector project, the financial internal rate of return is to be maximized from the point of view of the private sector. In this case, some consideration must be given to various conditions that the private sector may want to impose, as those may affect the IRR, which is to maximize; this indicator too is measurable on an cardinal scale.

- Technical impact

There are quite obviously an infinite number of possible transport infrastructure arrangements that can be applied in response to the future transportation demands of a given region. These facilities will themselves modify demand. In attempting to develop an optimal system, however, the transportation planners are unable to generate but a few of the infinite variations that could be used. The technical impact of various alternatives has to be *maximized* taking into consideration the following requirements of technical innovation:

-adapting new technology concerning the means of transport (vehicles),
-applying new types of modes of transport (combined transport),
-adapting new means for upgrading the performance and service of theexisting modes of transport,
-adaptation of environment friendly technical solutions,-adaptation of new types of organization and provision of transportservices and/or traffic management,
-flexibility in responding to the changing demands.

This criterion can be *measured* on an *ordinal scale*.

- Environmental impact

Environmental costs are in the forefront of the social costs associated with the transport infrastructure. By producing fuel to propel motor vehicles internal combustion engines one pollutes the environment with noise and exhaust gases. In addition, the transport infrastructure occupies space. The area used is lost to farming affects ground water levels and biodiversity. The chain of effects begin with the emission of pollutants, which are transmitted by air, land and water to the environment, perhaps undergoing transformation by synergistic processes at the same time, and occur as immission at the ultimate pollution side. Polluting elements have to be considered from a wide range of considerations:

-waste gas in the form of sulphur dioxide, carbon monoxide and dioxide, nitrogen oxides, hydrocarbons, soot and dust or heavy metals;
-solids and liquid in the form of rubber and plastics, metals petrol and oil or acids;
-aerial pollutants which seal off surfaces, affect the water circuit, cut throughsettlement/colony structures or interrupt ecologicalrelationships;
-noise due to internal combustion engines, tire contact with road surfaces, breaking and hooting.

Sophisticated methods are needed to identify the proportional contribution of these elements in the total emission, a factor which are the basis for determining the causes and magnitude of damage.Environmental media not only carry the emitted pollutants over short and long distances but also provide the means for their storage accumulation by the combination of different pollutants. It should also be recalled that pollution impacts normally affect human beings, the ecosystem and material goods. The aggregated indicator of the main elements, mentioned above, can be *measured* on an *ordinal scale*. The value of the indicator has to *be minimize*d.

- Security/safety

A central problem of the transport activities is the significant number of accidents. Besides the environmental impact just discussed, mention should also be made of the other externalities, i.e. costs to « third parties », which do not figure as inputs in the transport production function, but which may be very important mostly in the cases of road, railway or airport projects. The reduction of serious accidents (especially the number of killed or injured persons) is a very important goal in the transport investment projects. The sum of direct and indirect costs of the safety-level concerning transport infrastructure project can be measured on a cardinal scale and its value has to be minimized.

AN EXHAUSTIVE SAMPLE OF TRANSPORT INFRASTRUCTURAL INVESTMENT PROJECTS

With the intention of doing a credible isomorphism between our modeling effort and the real transport infrastructural investment preoccupations, we have investigated the total list of

Hungarian transport infrastructure investment projects up to the end of 1994. An inter-ministerial committee, responsible for the quasi-equal spending of the limited financial sources for the most efficient development of transport infrastructure, continuously registers the incoming project propositions in a computerized information system. This list of projects is updated in every half year and contains only those demands for development items which had been previously investigated using for this purpose a prefeasibility study. Taking into account the budget sources of the transportation sector for the next planning period (cc. 8 billion HUF), and applying a strong pre-selection process for the total list of TIIPs, a set of different feasible transport infrastructure investment projects (including the adjacent investment costs) is selected. In this list, certain particulars of individual projects have been modified so as to abide by the confidentiality requirements of the inter-ministerial committee, reason that in this paper a subset of 20 different projects are considered.

In order to adequately rank infrastructure projects, taking into account all the multicriterion complexities, a flexible, changeable, modularly structured DSS is needed. Such a DSS accounts for the interest of different concerned groups of people, high quarters, authorities, institutions, as well as for the« homogenization »of payoutflows attached to the project grapes' cascade while respecting all the algorithmicallygenerated and/or technologically fixed outranking requirements.

MULTICRITERION ANALYSIS FRAMEWORK

The ranking problem of TIIPs can obviously be structured around the fundamental elements of ELECTRE II (Roy and Bertier [10]):

- $\mathbf{X}_{[m]} = \{X_1,..., X_i,..., X_m\}$, a finite set of *alternatives* to be ranked (i.e. TIIP's set);
- $\mathbf{Y}_{[n]} = \{Y_1,..., Y_j,..., Y_n\}$, a family of *criteria* with regard to which each alternative is evaluated

and

- $\mathbf{M}_{[mxn]} = \{M_{ij} = Y_j(X_i);\ i = 1\ldots,m;\ j = 1,\ldots,n\}$, a *performance matrix* of the alternatives evaluated objectively and/or subjectively, according to each of these criteria.

Moreover, we use the following subjective, decision maker (DM) defined elements:

- $\mathbf{W}_{[n]} = \{w_1,...,w_j,..., w_n\}$, a set of *weight*s (i.e. relative importances) associated

  with each criterion, where $\sum_{j=1}^{n} w_j = 1$ and $0 \le w_j \le 1$, $\forall j$, $j = 1,...,n$;

- three *concordance thresholds* C_1, C_2 and C_3 such as $0 < C_3 < C_2 < C_1 < 1$, as in Roy and Bertier [10]; Guigou [9] ;Kiss, Martel and Nadeau[3];
- two sets of *discordance thresholds* δ_j^U and δ_j^L with regard to each criterion such as $\delta_j^U > \delta_j^L$ and $\delta_j^U < \max |M_{ij} - M_{i^*j}|\ M_{ij}, M_{i^*j} \in \mathbf{M}_{[mxn]}$; $i \ne i^*$; $i,i^* \in [1\ldots,m]$
  $\forall j$, $j = 1,...,m$.

CLASSICAL OUTRANKING CONDITIONS

Define

1) three pointer-sets:

$$\bullet \mathbf{J}^{(+)}(X_i\ ;X_{i^*}) = \begin{cases} \{\, j\ |M_{ij} > M_{i^* j}\ \ i,i^* \in [1,\ldots, m],\ i \neq i^*; \forall j,\ j \in [1,\ldots,n]\} \text{ for all criteria to maximize ;} \\ \text{or} \\ \{j\ |M_{ij} < M_{i^* j}\ \ i,i^* \in [1,\ldots, m], i \neq i^*; \forall j,\ j \in [1,\ldots,n]\} \text{ for all criteria to minimize ;} \end{cases}$$

$$\bullet\ \mathbf{J}^{(=)}(X_i;X_{i^*}) = \{j\ |\ M_{ij} \ = M_{i^* j}\ ;\ _{i^* j}\ \ i,i^* \in [1,\ldots, m],\ \ i \neq i^*;\ \forall j,\ j \in [1,\ldots,n]\}\ ;$$

and

$$\bullet \mathbf{J}^{(-)}(X_i\ ;X_{i^*}) = \begin{cases} \{\, j\ |M_{ij} < M_{i^* j}\ \ i,i^* \in [1,\ldots, m],\ i \neq i^*; \forall j,\ j \in [1,\ldots,n]\} \text{ for all criteria to maximize ;} \\ \text{or} \\ \{j\ |M_{ij} > M_{i^* j}\ \ i,i^* \in [1,\ldots, m], i \neq i^*; \forall j,\ j \in [1,\ldots,n]\} \text{ for all criteria to minimize.} \end{cases}$$

2) three power metrics:

$\bullet\ W^{(=)}(X_i;X_{i^*}) = \sum_{j \in J^{(=)}}$ the neutralising power between X_i and X_{i^*}

$\bullet\ W^{(+)}(X_i;X_{i^*}) = \sum_{j \in J^{(+)}}$ the preponderant power of X_i over X_{i^*}

$\bullet\ W^{(-)}(X_i;X_{i^*}) = \sum_{j \in J^{(-)}}$ the preponderant power of X_{i^*} over X_i

3) a global concordance index:

$$\bullet\ c(X_i;X_{i^*}) = W^{(+)}(X_i;X_{i^*}) + W^{(=)}(X_i;X_{i^*})$$

and

3) local discordance indexes:

$$\bullet\ \Delta_j(X_i;X_{i^*}) = \begin{cases} M_{i^* j} - M_{ij} \text{ for all criteria to maximize;} \\ M_{ij} - M_{i^* j} \text{ for all criteria to minimize} \end{cases}$$

Given these definitions, we can specify in pseudo-code syntax the well known outranking conditions as follows:

If

$$\begin{cases} W^{(+)}(X_i;X_{i^*}) \geq W^{(-)}(X_i;X_{i^*}) \text{ and} \\ c(X_i;X_{i^*}) \geq C_1 \text{ and} \\ \Delta_j(X_i;X_{i^*}) \leq \delta_j^L; \forall_j, j=1,...n, \end{cases}$$

then

X_i *strongly outranks* X_{i^*} i.e.($X_i\ \mathbf{P}^{(S)} X_{i^*}$)

else

if

$$\begin{cases} W^{(+)}(X_i;X_{i^*}) \geq W^{(-)}(X_i;X_{i^*}) \text{ and} \\ c(X_i;X_{i^*}) \geq C_2 \text{ and} \\ \delta_j^L > \delta_j^U; \forall_j, j=1,...n, \end{cases}$$

or

$$\begin{cases} W^{(+)}(X_i;X_{i^*}) \geq W^{(-)}(X_i;X_{i^*}) \text{ and} \\ c(X_i;X_{i^*}) \geq C_3 \text{ and} \\ \Delta_j(X_i;X_{i^*}) > \delta_j^U; \forall_j, j=1,...n, \end{cases}$$

then

X_i *weakly outranks* X_{i^*} i.e.($X_i\ \mathbf{P}^{(W)} X_{i^*}$)

else

X_i and X_{i^*} are *indifferent* or *incomparable* i.e. ($X_i\ \mathbf{I}\ X_{i^*}$)

end if

end if

Taking into account the large-scale conception status of the TIIPs, it is pragmatically tolerable if only the strong outranking relations are effectively considered as preference (precedence) relations. Once the multicriterion analysis process (MAP) is completed, a dialogue between the DM and the system can begin. This procedure enables the DM to revise the previously generated preference - relation pair set (PRS) by the MAP and/or to modify the PRS by eliminating or by adding some preference constraints.

It seems necessary for us to point out that our conception is DM oriented specially concerning the outranking relations validity. To avoid the perverse effect of algorithmic assistance, the DM must confirm the « legitimacy » of each of the algorithmically generated outranking relations, therefore $(X_i\ \mathbf{P}^{(S)}\ X_{i^*})$, $(X_i\ \mathbf{P}^{(W)}\ X_{i^*})$, $X_i\ \mathbf{I}\ \ X_{i^*})\ \forall i, i^*; i, i^* \in [1,..., m], i \neq i^*$. The front services of our software offer this possibility to the DM in a user friendly way. If ever the DM does not wish to intervene, naturally in this case, the *ex-aequo elements are placed in order by the algorithm on the basis of the weakest outranking relations.*

ALGORITHMIC DESIGN

Let us consider the preference - relation pair set (PRS) generated in the framework of the previously described multicriterion analysis process (MAP) and eventually revised by the DM in the framework of pairwise comparisons in relation to the set of TIIP:

$$R(\mathbf{P})_{[c]} = \Gamma_{\S}(M_{[mxn]} = \left\{(X_i \mathbf{P} X_j)_z \middle| i, j \in [1,\dots,m]; i \neq j ; z = 1,\dots,c; 1 \leq c \leq \binom{m}{2} \right\}$$

where

m = cardinality of TIIP's set (i.e the number of projects);

n = number of criteria;

$M_{[mxn]}$ = m x n cardinal matrix containing the projects' evaluations in relation to the criteria;

$\Gamma_{\S}$ = MAP's algorithm ;

X_i = the ith project descriptor considered in TIIP's set , i = 1,...,m;

P = preference operator;

c = number of pairs, attached by the **P** operator;

$R(\mathbf{P})_{[c]}$ = c cardinal set containing the attached pairs by the **P** operator

When a PRS is used to obtain a ranking of TIIPs, it is most important to use a procedure to *detect possible circuits* in the oriented graph associated with this PRS. We use a simple and easy programmable detection procedure applied in Kiss - Martel and Nadeau [3] and based on the fact that the equivalence class of a vertex X_i is defined by the intersections between the set of the vertexes which can be arrived at, starting from X_i (i.e. direct transitive closing) and the set of the vertexes from which X can be arrived at (i.e. inverse transitive closure). A circuit is detected if this intersection is not empty.

By applying an aggregative decomposition procedure (Kiss and Martel, [2]; Martel and Kiss, [4]) to the PRS, we obtain a partition of TIIP's elements as a ν - part graph (i.e. direct decomposition)

$$\mathbf{D}_{[\nu]} = \psi_{\S}\left(R(\mathbf{P}_{[c]})\right) = {}_{k=1}^{\nu}\supset D_{k[\mu_k]} = \bigcup_{i=1}^{m} X_i \text{ and } \sum_{k=1}^{\nu}\eta_k = m \text{ ; } D_{k[\eta_k]} \bigcap D_{r[\mu_r]} = \{\emptyset\}$$

where

ν = number of resulting hierarchical levels;

$D_{k[\eta_k]}$ = kth hierarchical level (each level contains $\eta_k \geq 1$ elements originating TIIP's set);

$\psi_{\S}$ = aggregative decomposition algorithm, based in the following principle :

Convert a circuit-free oriented graph (with any arbitrary topology, to associating to $R(\boldsymbol{P})_{[c]}$ to an ordered multi-part graph. The transformation is done hrough a search and sequential separation of vertices whose external semi-degrees are zero.

For various reasons the generated *PRS is generally incomplete*. Then *from an incomplete PRS, many different hierarchical structures may be derived* (and, conversely, several PRS may stem from a single hierarchical structure). It is precisely this *non-mutual congruity* and the multitudinous decomposition possibilities that we wish *to exploit by adding a quasi-equal financial expenses' rythm-constraint to the generated PRS constraints.*

Given the ranking problem of a finite set of transport infrastructural investment projects (TIIP):

subject to

1) the PRS constraints

and

2) a quasi-equal financial expenses' rhythm constraint.

In order to help the decision maker facing such a particular ranking problem, we have simultaneously developed two DSS oriented algorithms. The first is based on a heuristic, exhaustive computational approach, whereas the second represents a pure mathematical model based on a large scale linear programming approach. In order to respect the paper length constraint, we present only our heuristical computational approach

Computational process

Let the aggregative decomposition algorithm $\psi_{\S}$ be applied successively to $R(\boldsymbol{P})_{[c]}$ and to $R(\boldsymbol{P}^{-1})_{[c]}$. Therefore we obtain:

- a direct decomposition $\vec{\mathrm{D}}_{[\nu]} = \psi_{\S}\,\left(R(\mathbf{P}_{[c]})\right)$ on the one hand and
- an inverse decomposition $\overleftarrow{\mathrm{D}}_{[\nu]} = \psi_{\S}\,\left(R(\mathbf{P}^{-1}_{[c]})\right)$ on the other.

The decompositions $\vec{\mathrm{D}}_{[\nu]}$ and $\overleftarrow{\mathrm{D}}_{[\nu]}$ are rarely identical. That being the case, then the only « better » hierarchical structure has been obtained and we cannot introduce the quasi-equal financial expenses' rhythm-constraint into the model. However, the most frequent case is rather the non-coincidence between $\vec{\mathrm{D}}_{[\nu]}$ and $\overleftarrow{\mathrm{D}}_{[\nu]}$. Consequently, the search for a compromise hierarchical structure $\vec{\mathrm{D}}^{\otimes}_{[\nu]}$ satisfying the quasi- equal financial expenses' rhythm constraint is justified.

Whatewer $\vec{\mathrm{D}}_{[\nu]}$ and $\overleftarrow{\mathrm{D}}_{[\nu]}$ are obtained, the uniqueness or multiplicity of these decompositions can be directly verified by calculating the $\kappa \in \mathbf{I}^{(+)}$ multiplicity coefficient, as follows:

$$\kappa \le \prod_{i=1}^{m} (\lambda_i^+ - \lambda_i^- + 1)\text{, with } 1 \le \lambda_i^- \le \nu \;\; ; 1 \le \lambda_i^+ \le \nu \text{ and } \lambda_i^- \le \lambda_i^+ \;\; ; \mathrm{i} = 1,\ldots,\mathrm{m},$$

where

λ_i^- = hierarchical place of the i th project in $\overleftarrow{D}_{[\nu]}$;

λ_i^+ = hierarchical place of the i th project in $\vec{D}_{[\nu]}$.

(The decomposition is unique if κ = 1 and multiple if κ > 1.)

When the κ > 1 condition persists, the system calculates for each one of the κ hierarchical structure constellations the Λ summarized value of the absolute deviations between the $\overline{\Phi}$ mean value and each Φ_k, k = 1,...,ν hierarchical level's summarized financial values in the following manner:

$$\Lambda_\tau = \sum_{k=1}^{\nu} \left| \overline{\Phi} - \Phi_k \right| = \sum_{k=1}^{\nu} \left| \overline{\Phi} - \left(\sum_{g=1}^{\eta_k} \Phi\left(\hat{D}_{k,g}\right) \right) \right| ; \quad \forall \tau; \tau = 1,...\kappa , \quad \text{with } \overline{\Phi} = \left\lfloor \left(\sum_{i=1}^{m} \Phi_i \right) \cdot \nu^{-1} \right\rfloor$$

where $\Phi\left(\hat{D}_{k,g}\right)$ represents the financial value of the $\hat{D}_{k,g}$ th project classified as g th element of k th hierarchical level; $\hat{D}_{k,g} \le m; k = 1,...,\nu; g = 1,...,\eta_k$. The Min($\Lambda$) $\in \{\Lambda_\tau; \tau = 1,...,\kappa\}$ points to a compromise hierarchical structure $\overleftrightarrow{D}_{[\nu]}^{\otimes}$ simultaneously satisfying the PRS constraints and the quasi-equal financial expenses' rhythm-constraint.

DIDACTICAL EXAMPLE

In order to illustrate the proposed treatment, we briefly present a didactical example, using the earlier described real criteria's set and real transport infrastructural investment projects' set .

Suppose that:

- we dispose some $R(\boldsymbol{P})_{[c=52]}$ set generated in the framework of MAP and revised by the DM in the framework of interactive user/machine dialogue in relation to the set of 20 different TIIPs. An aggregative decomposition procedure (Kiss - Martel, [2]; Martel - Kiss, [4]) applied to $R(\boldsymbol{P})_{[c]}$ and to $R(\boldsymbol{P}^{-1})_{[c]}$, we obtain two distinct decompositions (hierarchical structures, rankings) of the TIIPs in ν = 11 hierarchical levels (i.e. ordered ν-part graphs), and
- the multiplicity exist(i.e. $\vec{D}_{[\nu=11]} \neq \overleftarrow{D}_{[\nu=11]}$

As one supose the existence of multiplicity, an intermediate, compromise hierarchical structure (i.e.fractile structure) $\overleftrightarrow{D}_{[\nu]}^{\otimes}$ can be searching, rigorously satisfying the PRS constraints and minimizing the summarized value of the absolute deviations between the mean investment value and each hierarchical level's summarized financial values.

The end product $\overleftrightarrow{D}_{[\nu]}^{\otimes}$ may be detected either by exhaustive search using HCA or by iteration steps using LPA under the minimal value of Λ metrics. Thus, in the current example, only the engineering of desired quasi-uniform expenses rhythm ranking (see Fig. 1) and the distribution of investment expenses (see Fig.2)are presented. The $\vec{\mathrm{D}}^{\otimes}_{[\nu=11]}$ hierarchical structures satisfy at 100% accuracy the PRS constraints and the quasi-uniform expenses rhythm requirement.

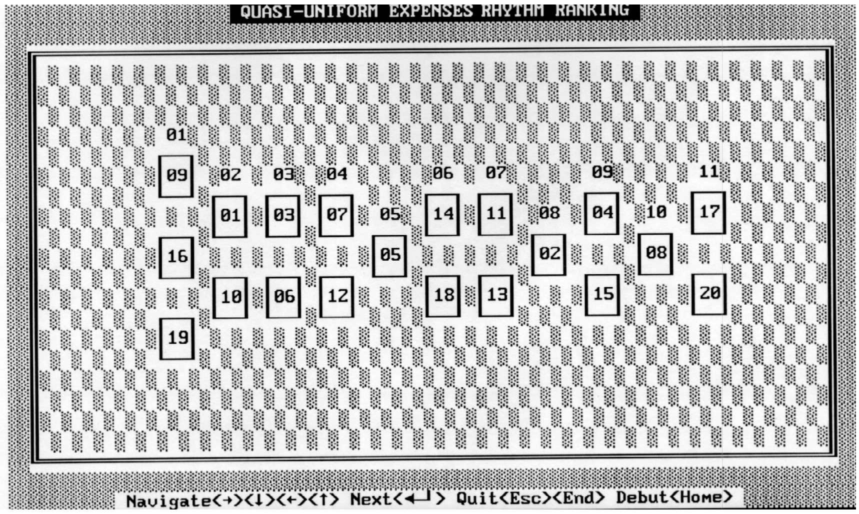

Fig.1. *Quasi-uniform expenses rhythm ranking*: $\vec{\mathrm{D}}^{\otimes}_{[\nu]} = \psi_{\S}\left(R(\mathbf{P}_{[c=52]}) \mid \mathrm{Min}(\Lambda\right)$

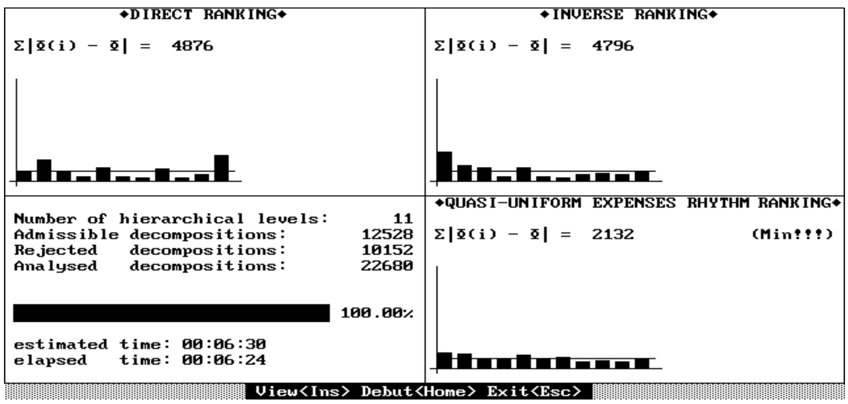

Fig.2 *Distribution of investment expenses*

CONCLUDING REMARKS

In the present research, we intentionally exploited the absence of a mutual congruity that can be observed between the relationships of algorithmically generated preferences, or else technologically imposed as revised, eventually modified by the deision maker snd the resulting hierarchical structures that rigourously satisfy not only the PRS, but also an economical constraint formulated later, like the homogenizes allocation of the financial ressources.

Our experimental results with real data exhibit the expected aspirations and draw a perspective for further possible applications, most probably, in employment and in achieving other macro-economic targets.

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