A MULTI-OBJECTIVE DECISION SUPPORT SYSTEM FOR PROJECT SELECTION WITH AN APPLICATION FOR THE TUNISIAN TEXTILE INDUSTRY

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1. Tunisian Development Planning as Illustrated by its Textile Industry

In this paper project selection is proposed as an answer to development planning. Project Selection assumes "that the project to be analysed will constitute a new economic activity…..in practice, however, many projects will only modify an existing economic activity" [42]. In addition different competing projects are considered and a final choice is made by Multiple Objective Optimization.

Project Selection is subject of an evolution concerning the objectives to strive after. If before the stress was put on market analysis, Net Present Value, Internal Rate of Return and other micro-economic targets, macro-economic objectives receive more and more attention such as employment, value added and the influence on the balance of payments. Attention for social well being goes even a step further with for instance environment and pollution. Employment is a human right, sometimes even written down in national constitutions.

In order to be more specific the Tunisian Textile Industry will be used as an illustration. Tunisia's industrial sector comprises 5,624 enterprises having 10 or more employees, including 2,095 enterprises in the textile and clothing industry (All figures for 2008 come from the Industry Promotion Agency and from Textile and Clothing Industries, Think Tunisia.). Of these 2,095 textile firms 1,752 work entirely for exportation; the remaining ones work for home consumption and exportation. In the sub-sector "manufacture of fabric and knitted wear" even 1,406 on 1,566 enterprises work totally for exportation. In the whole textile sector some 1,000 Tunisian companies work in partnership with EU companies: of which 365 are French, 206 Italian, 121 Belgian and 106 German.

On a total of 478,608 employees in total industry 200,230 or 42 % work in the textiles and clothing industries. For Value Added it goes in the other direction. The Value Added in the textiles and clothing industries amounted to 1,610 billion dinars in 2008 against 9 billion for the whole industry. Consequently against a labor productivity of 18,805 dinars per employee in the whole Tunisian industry stands only a labor productivity of 8,041 dinars per employee in the textile industry. Anyway a correlation is observed between the low pay and the off shoring from the European countries for the Tunisian textile industry. Bergin et al. [2] remark if off shoring, meaning outsourcing but abroad, takes place between the United States and Mexico it is also the case between the European countries and the emerging countries and in global trade with China.

Under these circumstances the Tunisian Government could promote textile firms with higher Value Added and lower employment, automatically meaning higher productivity. If in addition the government income could increase would be welcome too. Therefore a simulation will take into account multiple objectives even expressed in different units and facing different projects. Indeed, the Tunisian Ministry of Industry and Technology is always very active with enterprise creation under the form of an investor's guide, of launching project ideas, of legal assistance and of other forms of coaching (Industry Promotion Agency).

2. A Simulation Exercise for Enlarged Project Selection

Suppose the Government of Tunisia would have the choice to support one of three projects. The following objectives are proposed:

1) maximization of Net Present Value (NPV) at the end of the project period and expressed in money terms (in 1 million dinars):
   Net Present Value = discounted Revenues exclusive local and direct and indirect government taxes, inclusive rent on industrial land and depreciation, but minus investments;
2) maximization of the Internal Rate of Return (IRR) expressed as a % interest rate, considering NPV equal to zero at the end of the project period;
3) minimization of the Payback Period of NPV, expressed in years and months;
4) maximization of Government Income: local and direct and indirect government taxes in 100,000 dinars;
5) maximizing direct and indirect local and national employment in person-years; indirect employment found by local and national input-output tables;
6) maximizing the increase in Gross Domestic Product in 1 million dinars;
7) minimization of the risk on 5) and 6) in %;
8) maximization of increase in 100,000 dinars in the Balance of Payments;
9) maximization of hard currency to be provided by foreign sources for investment, expressed in money terms (in million dinars).
   Table 1 presents the three projects.

Tab. 1: Reaction of Three Projects on Nine Objectives for the Tunisian Textile Industry

	1	2	3	4	5	6	7	8	9
	NPV	IRR	Pay-back	Govern. Income	Employm.	V. A.	Risk	Bal.Paym.	Investm.
	MAX.	MAX.	MIN.	MAX	MAX.	MAX.	MIN.	MAX.	MAX.
A	1	14	9	200	600	20	20	3.5	2.5
B	1.6	16	7	150	800	13.5	25	4	1.5
C	2	17	5	80	1200	10	30	3.8	1.25

Source: own

The whole exercise is linked to a simulation. Contrary to a lot of other definitions, simulation is defined here in a rather broad sense. Gordon et al. [19] give the most complete description of simulation as mechanical, metaphorical, game or mathematical analogs. They conclude: "are used where experimentation with an actual system is too costly, is morally impossible, or involves the study of problems which are so complex that analytical solution appears impractical".

Project Management needs much more paper work than is shown here (see [42]). Brauers [13] made a pre-study for dyeing works in Tunisia as an example of application.

3. Why Using Multiple Objectives Optimization in Project Selection?

Cost-Benefit Analysis is the traditional used method. Cost-Benefit takes a monetary unit as the common unit of measurement for benefits and costs. In this way, cost-benefit presents a materialistic approach, whereby for instance unemployment and health care are degraded to monetary items. Multi-Objective Optimization will take care of the disadvantages of Cost-Benefit: *the objectives can keep their own units.*

In order to define an objective better we have to focus on the notion of *attribute*. Keeney and Raiffa [23] present the example of the objective "reduce sulfur dioxide emissions" to be measured by the attribute "tons of sulfur dioxide emitted per year". An attribute should always be measurable. Simultaneously we aim to satisfy multiple objectives, whereas several alternative solutions or projects are possible, characterized by several attributes. An alternative should be quantitatively well defined. An attribute is a common characteristic of each alternative such as its economic, social, cultural or ecological significance, whereas an objective consists in the optimization (maximization or minimization) of an attribute.

Economic Welfare (the term was invented by professor Pigou [31] comprises micro- and macroeconomics. Microeconomics would include attributes such as: yearly capacity to be reached, Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period. Macro-economics would include increase in GDP, surplus in the current account of the balance of payments, direct and indirect employment increase and ENPV. Indirect employment is measured by Input-Output techniques. ENPV means Economic Net Present Value, i.e. discounted revenues before national taxes, minus discounted investments, exclusive of subsidies. ENPV is different from GDP, but represents in macro-economics the counterpart of NPV, also with deduction of investments.

Satisfaction of all stakeholders is still another series of objectives. Stakeholders mean everybody interested in a certain issue. Due to consumer sovereignty and the economic law of decreasing marginal utility, consumer surplus, level of salaries, leisure time and again employment at the local and national level have to be taken into consideration.

Some attributes like NPV, ENPV, GDP, balance of payments surplus and consumer surplus are expressed in money terms, like dollars or Euros. However, a Euro in consumer surplus cannot be compensated for instance with a GDP-Euro. In addition, IRR is expressed in a percentage, the payback period in months or years, employment in number of persons per year, production, for instance, in TEU, etc. Consequently, a serious problem of normalization is present.

Normalization means reduction to a normal or standard state. However, the term got many interpretations but the stress is mainly put on the unification of diverting systems of measurement. As decision making is interested in measurement, normalization in technology is a main starting point, whereas scales of measurement and measurement of quality may be troublesome (for more on normalization, see: Brauers [9]).

4. Conditions of Robustness in Multi-Objective Methods

For the researcher in multi-objective decision support systems the choice between many methods is not very easy. Indeed numerous theories were developed since the forerunners: Condorcet [15] (the Condorcet Paradox, against binary comparisons), Gossen [20] (law of decreasing marginal utility) Minkowski [27, 28] (Reference Point) and Pareto [30] (Pareto Optimum and Indifference Curves analysis) and pioneers like Kendall [24] (ordinal scales), Roy et al. [34] (ELECTRE), Miller and Starr [26] (Multiplicative Form), Hwang and Yoon [21] (TOPSIS), Saaty [35] (AHP) and Opricovic and Tzeng [29] (VIKOR).

We intended to assist the researcher with some guidelines for an effective choice. Indeed, elsewhere we tried to define robustness in connection with multiple objectives [5] and seven conditions of robustness were set [6]. MOORA seemed to satisfy these seven conditions of robustness. The tests were made as non-subjective as possible, but as the authors of this article were involved in setting up the test, it seemed better to avoid any impression of favoritism. Therefore Chakraborty [16], as an outsider, could judge better about MOORA. Chakraborty [16] took up the seven conditions of robustness and checked six famous methods of Multi-Objective Decision Making for decision making in manufacturing. Table 2 shows the results.

5. The Data Assembled in a Matrix

A matrix under the form of a table assembles the data with vertically numerous objectives, criteria (a weaker form of objectives) or indicators and horizontally alternative solutions like projects.

The data originate from statistics, desk research, Project Engineering [41] or from simulated figures. In this way, alternatives, solutions or projects enter the response matrix as rows. When it concerns projects information has to be as complete as possible. Otherwise imagination has to be intensive eventually with the assistance of the Ameliorated Nominal Group Technique (see Appendix A).

Some of the candidate alternatives are excluded if they do not respond to conditions concerning lower bounds or upper limits. All constraints concerning lower bounds or upper limits have to be hard constraints, which form a sine qua non for the acceptance of the candidate alternatives [38]. Distinction has to be made between qualitative and quantitative hard constraints. On the one hand, investments

Tab. 2: Comparative Performance of Some MODM Methods

MODM	Computational time	Simplicity	Mathematical calculations	Stability	Information type
MOORA	Very less	Very simple	Minimum	Good	Quantitative
AHP	Very high	Very critical	Maximum	Poor	Mixed
TOPSIS	Moderate	Moderately critical	Moderate	Medium	Quantitative
VIKOR	Less	Simple	Moderate	Medium	Quantitative
ELECTRE	High	Moderately critical	Moderate	Medium	Mixed
PROMETHEE	High	Moderately critical	Moderate	Medium	Mixed

Source: own

Tab. 3: Matrix of Responses

	obj.1	**obj. 2**	**...**	**obj. i**	**...**	**obj. n**
Alternative 1	X_{11}	X_{21}	...	X_{i1}	...	X_{n1}
Alternative 2	X_{12}	X_{22}	...	X_{i2}	...	X_{n2}
....	X...	X...	...	X...	...	X...
Alternative j	X_{1j}	X_{2j}	...	X_{ij}	...	X_{nj}
....	X...	X...	...	X...	...	X...
Alternative m	X_{1m}	X_{2m}	...	X_{im}	...	X_{nm}

Source: own

needed in a well-defined region and not in other regions, complete financial guaranties to be given for daughters of multinationals in case of failure, represent examples of qualitative hard constraints.

On the other side, certain capacities in production not to be exceeded unless new investments are made. The World Bank granting a loan to a developing country unless for instance at least an Internal Rate of Return of 12 % is guaranteed, geometrical constraints under the form of a limiting line, surface or manifold, represent quantitative hard constraint examples.

6. How to Determine the Objectives?

The question remains how to find and how to decide on the choice of the objectives. One decision maker like a captain of industry will focus on his own objectives. Different decision makers do not change the picture. In some industrial countries the large companies are obliged to have in the board of directors some directors from outside the company. Even this group of decision makers will stick to their own limited objectives. For the choice of the objectives, certainly a necessity when the General Well Being is concerned, all stakeholders, which mean all persons interested in a certain issue, have to be involved.

The choice of stakeholders in a Nominal Group Technique exercise for the Facilities Management Sector of Lithuania on October 15, 2002 forms an example of application. Fifteen delegates from the facilities sector itself, from the ministerial departments concerned and from the academic world came together during an afternoon to pronounce themselves about the objectives of the sector until 2012 [11]. The absence of a consumer representation formed a weak point, but at that time no representative consumer organization existed in Lithuania. Concerning the employees trade unions were not interested as the facilities sector in Lithuania is composed of only small firms. The more neutral academic representatives were assumed to represent the consumer interest.

The original NGT as introduced by Van De Ven and Delbecq [37] delivered a total of 225 points. The total 225 is a control figure for the group result. Indeed, each participant could distribute maximum: 5+4+3+2+1 = 15 points. With 15 participants, the total has to be not more than 225. It could be less, as each participant is not obliged to allot 15 points. The total of the given points, here namely 225, means that each participant used his rights completely.

Applying the Ameliorated Nominal Group Technique with the introduction of probabilities of realization, introducing a sense of reality and presenting a guaranty against wishful thinking, produces quite some changes in the ranking. This reality check diminished the total to 145 points. (Appendix A brings information on the Ameliorated Nominal Group Technique).

For the choice of the objectives sometimes a general consensus is reached in the specialized literature or in the legislation.

Once agreement reached about alternatives and objectives, a decision has to be taken how to read the Response Matrix (see table 3 above), either horizontally or vertically.

6.1 Horizontal Reading of the Response Matrix

SAW and usual Reference Point Methods read the response matrix in a horizontal way. The Additive Weighting Procedure (MacCrimmon [25] which was called SAW, Simple Additive Weighting Method, by Hwang and Yoon [21]) starts from:

$$Max.U_j = w_1x_{1j} + w_2x_{2j} + ... + w_1x_{1j} + ... + w_nx_{nj}$$

U_j = overall utility of alternative j with j = 1,2, …..,m, m the number of alternatives

w_i = weight of attribute i indicates as well as normalization as the level of importance of an objective

i = 1,2,…..,n; n the number of attributes and objectives

x_{ij} = response of alternative j on attribute i.

As the weights add to one a new super-objective is created and consequently it gets difficult to speak of multiple objectives.

Traditional Reference Point Theory is non-linear, whereas non-additive scores replace the weights. The non-additive scores take care of normalization and of importance. But being non-additive the comments on the weights adding to one and consequently creating a super-objective is absent here.

With weights and scores importance of objectives is mixed with normalization. Indeed weights and scores are mixtures of normalization of different units and of importance coefficients.

6.2 Vertical Reading of the Response Matrix

Vertical reading of the Response Matrix means that normalization is not needed as each column is expressed in the same unit. In addition if each column is translated into ratios dimensionless measures are created and the columns become comparable to each other. Indeed they are no more expressed in a unit. Different kind of ratios are possible but Brauers and Zavadskas [9] proved that the best one is based on the square root in the denominator.

The Ratio System which forms the basis of the MOORA method follows the vertical reading of the matrix.

Diagram I (Fig. 1) shows the exact relation between the two methods of MOORA and in addition to MULTIMOORA (MOORA plus the Full Multiplicative Form, method to be explained later).

7. Multi-Objective Optimization by Ratio Analysis (MOORA)

7.1 The Two Parts of MOORA

The method starts with a matrix of responses of different alternatives on different objectives:

$$(x_{ij})$$

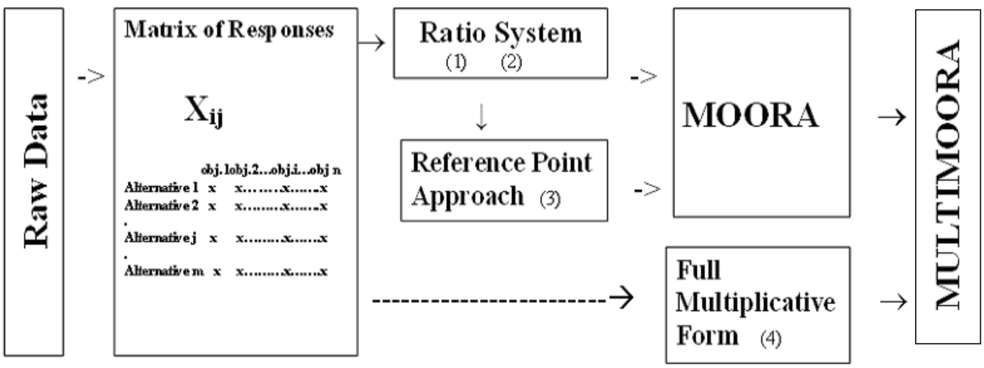
with: x_{ij} as the response of alternative j on objective i

$i=1,2,…,n$ as the objectives

$j=1,2,…,m$ as the alternatives

MOORA goes for a ratio system in which each response of an alternative on an objective

Fig. 1: Diagram of MULTIMOORA



Source: own

is compared to a denominator, which is representative for all alternatives concerning that objective. For this denominator the square root of the sum of squares of each alternative per objective is chosen. Brauers and Zavadskas [9] proved that this is the most robust choice:

$$x_{ij*} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m} x_{ij}^{2}}} \qquad (1)$$

with: x_{ij} = response of alternative *j* on objective *i*
j = 1,2,...,m; m the number of alternatives
i = 1,2,…n; n the number of objectives
x_{ij}^* = a dimensionless number representing the normalized response of alternative j on objective i.

Dimensionless Numbers, having no specific unit of measurement, are obtained for instance by deduction, multiplication or division. The dimensionless responses of the alternatives on the objectives belong to the interval [0; 1]. However, sometimes the interval could be [-1; 1]. Indeed, for instance in the case of productivity growth some sectors, regions or countries may show a decrease instead of an increase in productivity i.e. a negative dimensionless number.

For optimization these responses are added in case of maximization and subtracted in case of minimization:

$$y_j^* = \sum_{i=1}^{i=g} x_{ij*} - \sum_{i=g+1}^{i=n} x_{ij*} \qquad (2)$$

with: *i* = 1,2,…,g as the objectives to be maximized;
i = *g*+1, *g*+2,…, n as the objectives to be minimized;
y_j^*= the normalized assessment of alternative j with respect to all objectives.

A ranking of the y_j^* in a descending order will show the final preferences in MOORA.

For the second part of MOORA the Reference Point Theory is chosen with the Min-Max Metric of Tchebycheff as given by the following formula (Karlin and Studden [22])

$$\underset{(j)}{Min}\left\{\underset{(i)}{\max}\left| r_i - x_{ij*} \right|\right\} \qquad (3)$$

with $|r_i - x_{ij}^*|$ the absolute value if x_{ij}^* is larger than ri for instance by minimization.

This reference point theory starts from the ratios as defined in the MOORA method, namely formula (1). Preference is given to a reference point possessing as co-ordinates the dominating co-ordinates per attribute of the candidate alternatives and which is designated as the Maximal Objective Reference Point. This approach is called realistic and non-subjective as the co-ordinates, which are selected for the reference point, are realized in one of the candidate alternatives. The alternatives A (10; 100), B (100; 20) and C (50; 50) will result in the Maximal Objective Reference Point R_m (100; 100).

Finally the Minima obtained by the Reference Point Method are ranked in an ascending order.

7.2 The Importance Given to an Objective by the Attribution Method in MOORA

It may look that one objective cannot be much more important than another one as all their ratios are smaller than one (see formula 1) Nevertheless it may turn out to be necessary to stress that some objectives are more important than others. In order to give more importance to an objective its ratios could be multiplied with a *Significance Coefficient*.

In the Ratio System to give more importance to an objective its response on an alternative under the form of a dimensionless number could be multiplied with a Significance Coefficient:

$$\ddot{y}_j{}^* = \sum_{i=1}^{i=g} s_i x_{ij}{}^* - \sum_{i=g+1}^{i=n} s_i x_{ij}{}^* \quad \text{(2 bis)}$$

with: i = 1,2,…,g as the objectives to be maximized.

i = g+1, g+2,…, n as the objectives to be minimized.

s_i = the significance coefficient of objective i.

$\ddot{y}_j{}^*$ = the total assessment with significance coefficients of alternative j with respect to all objectives.

For the Reference Point Approach the place of the significance coefficient would be:

$$| s_{jr} – s_i x_{ij}{}^* |$$

The method with Significance Coefficients has to be based on a Delphi exercise with all the stakeholders in order to determine the importance of the objectives (for the Delphi Method see Appendix B).

One could think of aggregating all possible dimensionless methods in a single multi-objective system, for instance called MULTIMOORA. In this way MULTIMOORA would become the fulfillment of the seven robustness conditions on the basis of more than two methods.

8. MULTIMOORA

MULTIMOORA is composed of MOORA and of the Full Multiplicative Form of Multiple Objectives. MULTIMOORA becomes a very robust system of multiple objectives optimization under condition of support from the Ameliorated Nominal Group Technique and Delphi (see Appendices A and B).

8.1 MOORA

MOORA (Multi-Objective Optimization by Ratio Analysis) was explained under point 7.1 above.

8.2 The Full Multiplicative Form of Multiple Objectives

Economics is familiar with the multiplicative models like in production functions (e.g. Cobb-Douglas and Input-Output formulas, Brauers [12]) and demand functions (Teekens and Koerts [36]), but the multiplicative form for multi-objectives was introduced by Miller and Starr in 1969 [26] and further developed by Brauers in 2004 [10].

The following *n*-power form for multi-objectives is called from now on a *full-multiplicative* form in order to distinguish it from the mixed forms:

$$U_j = \prod_{i=1}^{n} x_{ij} \quad (4)$$

with: *j* = 1, 2,...,*m; m* the number of alternatives;

i = 1, 2,…, *n; n* being the number of objectives;

x_{ij} = response of alternative *j* on objective *i* (x_{ij} = 0 means that an objective is not present in an alternative. A foregoing filtering stage can prescribe that an alternative with a missing objective to be maximized is withdrawn from the beginning. Otherwise for the calculation of a maximum the zero factor is just left out. A zero in a minimization problem is much more complicated. A real zero factor, like in the case of the absence of pollution, has to maintain its influence. Therefore the zero factor will receive an extremely low symbolic value like 0.01. If the zero factor means missing information then the situation is different and will ask for a serious correction. A correction factor has to be introduced being a bit larger than the corresponding factors of the other alternatives, for instance next ten, next hundred etc. With factors 8 and 11 next ten will be 20. With factors 80 and 110 next hundred will be 200 etc. Pollution can even be negative for a country which can offer drawing rights on pollution. However the situation can then be reversed. If pollution has to be minimized the possession of drawing rights can be maximized.)

U_j = overall utility of alternative *j*.

The overall utilities (U_j), obtained by multiplication of different units of measurement, become dimensionless.

How is it possible to combine a minimization problem with the maximization of the other objectives? Therefore, the objectives to be minimized are denominators in the formula:

$$U_j^{'} = \frac{A_j}{B_j} \tag{5}$$

with: $A_j = \prod_{g=1}^{i} x_{gi}$

j = 1,2,...,*m; m* the number of alternatives;

i = the number of objectives to be maximized

with: $B_j = \prod_{k=i+1}^{n} x_{kj}$

n-i = the number of objectives to be minimized;

with: U_j' : the utility of alternative *j* with objectives to be maximized and objectives to be minimized.

The Full Multiplicative Form is read horizontally in the Response Matrix of Table 3 (see above). Nevertheless with the full-multiplicative form, the overall utilities, obtained by multiplication of different units of measurement, become dimensionless measures. This situation would not bias the outcomes amidst the several alternatives as the last ones are represented by dimensionally homogeneous equations, being: "formally independent of the choice of units" [18]. Additionally, any attribute of size 10^{exp} can be replaced by size 1 without changing the relation between the alternatives and consequently with no influence on their rankings (proved by Miller and Star [26]; also Brauers [10]). Does it mean that importance to an objective can not be given in the Full Multiplicative Form?

Stressing the importance of an objective can be done by allocating an exponent (a *Significance Coefficient*) on condition that this is done with unanimity or at least with a strong convergence in opinion of all the stakeholders concerned (see Appendix B).

A ranking of the U_j' in a descending order will show the final preferences in the Full Multiplicative Form.

8.3 MULTIMOORA as a Synthesis of the Results of the Ratio System, the Reference Method and the Full Multiplcative Form

The three methods of MULTIMOORA are assumed to have the same importance. Stakeholders or their representatives like experts may give a different importance to objectives but this is not the case with the three methods of MULTIMOORA. These three methods represent all existing methods with dimensionless measures in multi-objective optimization and one is not better than the other. Consequently, all the three have the same significance of importance.

Using for MULTIMOORA the total of the ranks of the ratio system, of the reference point and of the multiplicative form would mean working ordinal and not cardinal. Indeed, preference for cardinal numbers is rather based first on the saying of arrow [1]: “Obviously, a cardinal utility implies an ordinal preference but not Vice Versa” and second on the fact that the four essential operations of arithmetic: adding, subtracting, multiplication and division are only reserved for cardinal numbers (see Brauers and Zavadskas [4]; Brauers and Ginevicius [6]; Brauers [8]).

In the most of the not too complicated cases a synthesis of the ranking of the three

MULTIMOORA methods can be made. For very large matrices Brauers et al. developed a *Theory of Dominance* [3], [4].

Finally the results of MULTIMOORA, found as a synthesis, are ranked in a descending order.

8.4 MULTIMOORA as applied for the Tunisian Textile Projects

Appendices C and D give the detailed tables for MOORA and the Multiplicative Form concerning the projects for the Tunisian Textile Industry. Neither Project A, B or C is overall dominating, which means that a multi-objective ranking has to bring the solution. Project A is the best for higher Value Added and lower employment, automatically meaning higher productivity. In addition the government income increase is welcome too. Project C is condemned as labor productivity is very low due to high employment and low Value Added. Project B shows an in between solution. Table 4 gives the reaction of the projects on the objectives after the MULTIMOORA approach, a synthesis of the three methods.

Tab. 4: The Reaction of the Projects on the Objectives after the MULTIMOORA Approach

Projects	MOORA Ratio System	MOORA Reference Point	Multiplicative Form	MULTIMOORA
A	1	2	1	1
B	2	1	2	2
C	3	3	3	3

Source: own

As in MULTIMOORA an equal importance is given to each of the three methods, then A is general dominating B on two of the three methods. B takes an in between solution. Project C comes in the last position in spite of its favorable employment total.

Conclusion

For a researcher in multi-objective decision support systems the choice between many methods for multi-objective optimization is not very easy. We intended to assist the researcher with some guidelines for an effective choice. In order to distinguish the different multi-objective methods from each other we use a qualitative definition of robustness, with an outsider judging favorably on MULTIMOORA, the method which was applied for a simulation on the Tunisian Textile Industry.

Multi-Objective Optimization by Ratio Analysis (MOORA), composed of two methods: ratio analysis and reference point theory starting from the previous found ratios, solves the difficult problem of normalization whereas the importance of the objectives is treated separately. If MOORA is joined with the Full Multiplicative Form for Multiple Objectives a total of three methods is formed under the name of MULTIMOORA, a mighty instrument for Multi-Optimization in a Well Being Society. In addition if MULTIMOORA is joined with the Ameliorated Nominal Group Technique and with Delphi the most robust approach exists for multi-objective optimization up to now.

If the Simulation Exercise on the Tunisian Textile Industry has no practical consequences, in any case it provides a learning experience with MULTIMOORA in its triple composition.

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Doručeno redakci: 7. 10. 2011
Recenzováno: 8. 11. 2011, 28. 11. 2011
Schváleno k publikování: 9. 1. 2012

Abstract

A MULTI-OBJECTIVE DECISION SUPPORT SYSTEM FOR PROJECT SELECTION WITH AN APPLICATION FOR THE TUNISIAN TEXTILE INDUSTRY

Willem Karel M. Brauers, Edmundas Kazimieras Zavadskas

A developing country like Tunisia needs development planning but it will have problems with a top down strategy. As an answer to this problem the paper proposes a Multi-Objective Decision Support System for Project Selection. Project Selection is subject to an evolution concerning the objectives to strive after. If before the stress was put on market analysis, Net Present Value, Internal Rate of Return and other micro-economic targets, macro-economic objectives receive more and more attention such as employment, value added and the influence on the balance of payments. Employment is a human right, sometimes even written down in national constitutions.

Traditional Cost-Benefit does not respond to these purposes. Indeed in Cost-Benefit all benefits (objectives) have to be translated into money terms, leading sometimes to immoral consequences. On the contrary Multi-Objective Optimization takes care of different objectives, whereas the objectives keep their own units. However different methods exist for the application of Multi-Objective Optimization. These methods were tested after their performance. MOORA (Multi-Objective Optimization by Ratio analysis) and MULTIMOORA (MOORA plus a Full Multiplicative Form), showed positive results; the more if they were assisted by Ameliorated Nominal Group and Delphi Techniques.

A simulation exercise for Tunisia illustrates the use of these methods. The needs of the Tunisian textile industry are analyzed and as an answer three projects facing multiple objectives are simulated.

Key Words: *Project Selection, Cost-Benefit, Robustness, Multi-Objective Optimization, Ameliorated Nominal Group and Delphi Techniques, Full Multiplicative Form, MOORA, MULTIMOORA.*

JEL Classification: *C44, O14, O16, O22.*

Appendix A

The Ameliorated Nominal Group Technique as a source for objectives

A.1 The Original Nominal Group Technique of Van de Ven and Delbecq (1971)

A group of especially knowledgeable individuals representing all the stakeholders, is formed, which comes together in a closed meeting. A steering panel or a panel leader leads the group.

The nominal group technique consists of a sequence of steps, each of which has been designed to achieve a specific purpose.

1) The steering group or the panel leader carefully phrases as a question the problem to be researched. Much of the success of the technique hinges around a well-phrased question. Otherwise the exercise can easily yield a collection of truisms and obvious statements. A successful question is quite specific and refers to real problems. The question has to have a singular meaning and a quantitative form as much as possible.
2) The steering group or the panel leader explains the technique to the audience. This group of participants is asked to generate and write down ideas about the problem under examination. These ideas too have to have a singular meaning and a quantitative form as much as possible. Participants do not discuss their ideas with each other at this stage. This stage lasts between five and twenty minutes.
3) Each person in round-robin fashion produces one idea from his own list and eventually gives further details. Other rounds are organized until all ideas are recorded.
4) The steering group or the panel leader will discuss with the participants the overlapping of the ideas and the final wording of the ideas.
5) The nominal voting consists of the selection of priorities, rating by each participant separately, while the outcome is the totality of the individual votes. A usual procedure consists of the choice by each participant of the n best ideas from his point of view, with the best idea receiving n points and the lowest one point. All the points of the group are added up. A ranking is the democratic result for the whole group.

A.2 The Ameliorated Nominal Group Technique of Brauers (1987)

6) Out of experience, one may say that there is still much wishful thinking, even between the different stakeholders. Therefore the stakeholders were also questioned about the probability of realization of each objective. In this way they became more critical even about their own ideas. The probability of the group is found as the median of the individual probabilities.
7) Finally, the group rating (R) is multiplied with the group probability (P) in order to obtain the effectiveness rate of the event (E):

$$R \times P = E$$

Once again, the effectiveness rates of the group are ordered by ranking. Experience proves that the introduction of probabilities decreases significantly the total number of points.

Appendix B

The Delphi Technique to Determine the Importance of an Objective

Delphi, so named after the Greek oracle, was first thought of as a tool for better forecasting. In this sense, it seems that the first experiments took place around 1948 [33]. Today Delphi is no longer limited to forecasting alone. Dalkey and Helmer at RAND Corporation first used Delphi in its present form around 1953 [17].

The Delphi Method is a method for obtaining and processing judgmental data. It consists of a sequenced program of interrogation (in session or by mail) interspersed with feedback of persons interested in the issue, while everything is conducted through a steering group.

The essential features of Delphi are the following:

1) the rather vague notion "persons interested in the issue" is interpreted by Quade as follows: "In practice, the group would consist of experts or especially knowledgeable individuals, possibly including responsible decision makers" [32];
2) the steering group treats anonymously the sources of each input;
3) inputs must as much as possible possess a single meaning and a quantitative form. The inputs with these characteristics are elicited with feedback in a series of rounds;
4) opinions about the inputs are evaluated with statistical indexes such as median and quartiles;
5) there is also a feedback of the statistical indexes with a request for re-estimation after consideration of reasons for extreme positions. The practice of Delphi reveals that after several rounds convergence is shown between the various opinions (one of the main advantages of the Delphi method);
6) there are two developments of Delphi: one is based on a meeting, the other on the sending of questionnaires. The organization of a meeting produces quicker results; the meeting, however, has to be organized in such a way that communication between the panel members is impossible. In order to increase even further the speed of the outcome of a meeting, an on-line computer could be installed. Everybody involved in the Delphi teamwork would have a desk terminal linked to a computer and would be able to look at a television screen giving the results calculated by the computer.

Convergence in opinion among the stakeholders to give more importance to an objective results from a Delphi exercise. Therefore, this exercise could provide the given objective with a Significance Coefficient. For instance, giving a significance coefficient to pollution abatement, the stakeholders are asked to give the following importance to pollution abatement:

0, 1, 2 or 3

Suppose that after several rounds convergence is reached on 3 (for an example concerning voting by a jury, see [7]).

Appendix C

Simulation of Project Planning by MOORA

Tab. 5: Simulation for the Ratio System (5a until 5c) and for Reference Point (5d-5e) of MOORA

5a – Matrix of Responses of Alternatives on Objectives: (x_{ij})

	1	2	3	4	5	6	7	8	9
	NPV	IRR	Pay-back	Govern. Income	Employm.	V. A.	Risk	Bal.Paym.	Investm.
	MAX.	MAX	MIN.	MAX	MAX.	MAX.	MIN.	MAX.	MAX.
A	1	14	9	200	600	20	20	3.5	2.5
B	1.6	16	7	150	800	13.5	25	4	1.5
C	2	17	5	80	1200	10	30	3.8	1.25

5b – Sum of Squares and their Square Roots

A	1	196	81	40,000	360,000	400	400	12.25	6.25
B	2.56	256	49	22,500	640,000	182.25	625	16	2.25
C	4	289	25	6,400	1,440,000	100	900	14.44	1.56
∑	7.56	741	155	68,900	2,440,000	682.25	1925	42.69	10.06
root	2.749545	27.221	12.45	262.4881	1562.05	26.12	43.875	6.533758	3.1721444

5c – Objectives Divided by their Square Roots and MOORA

										sum	rank
A	0.363696	0.5143	0.7229	0.761939	0.384	0.766	0.4558	0.536	0.788	2.93480	1
B	0.581914	0.5878	0.5623	0.571454	0.51215	0.5168	0.5698	0.612205	0.4728662	2.723	2
C	0.727393	0.6245	0.4016	0.304776	0.76822	0.3828	0.6838	0.581595	0.3940552	2.698	3

5d – Reference Point Theory with Ratios: co-ordinates of the reference point equal to the maximal objective values

r_i	0.727393	0.6245	0.4016	0.761939	0.76822	0.766	0.4558	0.612205	0.788110

5e – Reference Point Theory: Deviations from the reference point

										max.	rank min.
A	0.364	0.1102	0.3213	0	0.38411	0	0	0.0765	0	0.38411	2
B	0.145479	0.0367	0.1606	0.190485	0.25607	0.2489	0.1140	0	0.3152	0.3152442	1
C	0	0	0	0.457164	0	0.3828	0.2279	0.0306	0.3941	0.4571636	3

Appendix D

Simulation of Project Planning by the full Multiplicative Form

Tab. 6: The Full Multiplicative Form

	1	2	3	4	5	6	7	8	9
	MAX.	MAX.		MIN.		MAX.		MAX.	
Projects	NPV	IRR	3 = 1 x 2	Payback	5 = 3 : 4	Gov.Y	7 = 5x6	Employm.	9 = 7 x 8
A	**1**	**14**	14	**9**	1.55555556	200	311.111111	**600**	186666.667
B	**1.6**	**16**	25.6	**7**	3.65714286	150	548.571429	**800**	438857.143
C	**2**	**17**	34	**5**	6.8	80	544	**1200**	652800
10	11	12	13	14	15	16	17	18	
MAX.		MIN.		MAX.		MAX.			
VA	11= 9 x10	Risk	13= 11:12	B. of P.	15= 13x14	Investm.	17= 15x16	Result	Projects
20	3733333.33	**20**	186666.667	**3.5**	653333.333	**2.5**	1633333	**1**	A
13.5	5924571.43	**25**	236982.857	**4**	947931.429	**1.5**	1421897	**2**	B
10	6528000	**30**	217600	**3.8**	826880	**1.25**	1033600	**3**	C