MADM Models for Decision Making in Acquisitions

Dorin D. M. Banciu[1], **Mihaela Resteanu**[2]

[1] ROMATSA, 10, Ion Ionescu de la Brad Blvd., 013813, Bucharest, Romania
DorinBanciu@yahoo.com

[2] PIRAEUS BANK, 63A, Nicolae Caranfil, 014146, Bucharest, Romania
Mihaela.Resteanu@piraeusbank.ro

Abstract: In this paper some methodological aspects of taking decisions and the MADM model are brought to the reader's attention. The model is described in detail and its solving will refer to the Onicescu method. The application developed by the authors is an example of optimal products, services, and works acquisition. The optimization makes use of OPTCHOICE – pervasive software for MADM modeling and optimal choice problems solving.

Keywords: Decision Making, Multiple Attribute Decision Making, Assessment and Optimization, Acquisitions, Ruttier Transport.

1. Introduction

Decision making is a set of human activities, which, in essence, means being aware that there are several ways of acting in a given context, analyse their consequences in relation to a purpose, choice and implementation of the action considered to be optimal in an axiological vision adopted.

The main stages of this process are the following:

- *Triggering,* characterized by the realising the necessity to act in response to the occurrence of events bearing disturbance / aggression / changes / gains / losses / opportunities / etc.;
- *Decisional tension,* defined by the collective concern, most often instinctive and unconcerted, to perceive, even inaccurate or incomplete, the decisional problem caused by the triggering events;
- *Initial formulation of the decisional problem*, highlighted in slightly different informal versions, depending on the views of different actors involved in the decision, between whom the first conflicts of opinion may arise;
- *Enunciation* of the *formal decisional problem*, built through organized effort by the multitude of actors which are structured by harmoniously assigning official roles (decision makers, experts, consultants, executioners, etc.).
- *Solving of the formal decisional problem*, assuming the application of one or more methods able of providing alternative solutions which are determined by simulating the consequences of their implementation, eventually choosing the one considered optimal;
- *Implementation of the optimal decision*, following the evaluation of all actions taken in order to achieve the desired results;
- *Verification of the decision's correctness / completeness / optimality*, could conclude that the decisional process has been closed or may return to one of the previous stages.

These are general methodological steps in decision making but they occur in a stated paradigm. In the present case, the paradigm is Multiple Attribute Decision Making (MADM) [1, 2 and 3].

It can be stated, without being mistaken, that any formulation of the matter, which seeks choosing of an optimal object in relation to several attributes, according to a process that can be defined through an algorithm leads naturally to a MADM model.

2. MADM Decisional Tool

The MADM model has the following entities: The set of objects, a discrete and finite set with at least one element, in the case of assessment problems, and with at least two elements, in the case of optimal choice problems.

$O = \{o[i] \mid i = \overline{1,\mathbf{i}}\}$, where $\mathbf{i} = \mid O \mid = \text{Card } O$, every o[i] element being characterized by:

– code_o[i] = o[i] object's code;

– name_o[i] = o[i] object's name;

– description_o[i] = o[i] object's very short description;

– evaluation_o[i] = o[i] object's evaluation.

The set of attributes, a discrete and finite set of mutual independent elements, with at least one element.

A = {a[j] | $j = \overline{1, \mathbf{j}}$ }, where **j** = | A | = Card A, every a[j] element being characterized by:

– code_a[j] = a[j] attribute's code;

– name_a[j] = a[j] attribute's name;

– description_a[j] = a[j] attribute's very short description;

– expression_a[j] = a[j] attribute's expression mode. Cardinal expression means to estimate the attribute by real numbers. But there are a lot of situations when the cardinal estimation is not possible or is not necessary. Therefore, other expression modes were introduced: ordinal, Boolean, fuzzy and random variables;

– measure_unit_a[j] = a[j] attribute's measure unit;

– sense_a[j] = a[j] attribute's sense, where:

$$\text{sense\_a[j]} = \begin{cases} \text{"max"} & \text{if a[j] is considered the better} \\ & \text{for the largest value} \\ \text{"min"} & \text{if a[j] is considered the better} \\ & \text{for the smallest value} \end{cases}$$

- lim_a[j] = {(pes_a[j], opt_a[j])| $j = \overline{1, \mathbf{j}}$ }or lim_a[j] = {(opt_a[j], pes_a[j])| $j = \overline{1, \mathbf{j}}$ } = a[j] attribute's variation intervals. They depend on sense_a[j] as follows:

If sense_a[j] = "max" then pes_a[j] = inferior margin for a[j] and opt_a[j] = superior margin for a[j].

If sense_a[j] = "min" then opt_a[j] = inferior margin for a[j] and pes_a[j] = superior margin for a[j].

In conformity with the above definitions, the inferior and superior margins represent the worst respectively the better possible attribute values.

– weight_a[j] = a[j] attribute's absolute weight with the properties: 0 < weight_a[j] < 1 $(\forall) j = \overline{1, \mathbf{j}}$ and $\sum_{j=1}^{\mathbf{j}} \text{weight\_a[j]} = 1$.

One defines Imp*A* = { weight_a[j]| $j = \overline{1, \mathbf{j}}$ }.

The model building refers to the relation between the sets *O* and *A*. To express this relation is necessary:

The decision matrix.

OA = {value_oa[i,j]| $i = \overline{1, \mathbf{i}}$, $j = \overline{1, \mathbf{j}}$ }, every element from *OA* being characterized by:

- value_oa[i,j] = the a[j] attribute's value corresponding to the o[i] object.

In fact, the decision matrix express a function associating for every o[i] object a vector with attributes' values having **j** components, i.e. (value_oa[i,1], ..., value_oa[i,**j**). In such modality, the set of objects is described by the set of attributes.

In this moment, the classical MADM model is entirely defined. The problems generated by MADM model can have a high complexity level, even when there are only a few attributes. Once the number of attributes increases, the problem complexity increases considerably. This complexity increasing is a consequence of conflict between attributes. That is the majority of real cases. One object can rank high to a specific attribute and concurrently very low to another one.

The general goals in solving a MADM problem [4] can be:

G1: objects assessment;

G2: optimum / pessimum object(s) finding;

G3: objects ranking.

In the presented model context and by the finality of this paper, the goals are G1 and G2. It requires an assessment function $f : O \rightarrow R^{+}$. The function, in the vast majority of cases, is built upon global utility concept introduced by J. von Neumann and O. Morgenstern. One method which implicitly realizes such function is the following:

Onicescu method (with its code = m).

The two variants of this method start from the function $\text{place\_oa}[i, j] =$ the place of object o[i] in the ranking induced by the attribute a[j], $i = \overline{1, \mathbf{i}}$, $j = \overline{1, \mathbf{j}}$ (taking in consideration its sense), $\text{place\_oa} : \{1.., i\} \times \{1..., j\} \to \mathbf{N}$. It should be noticed that if two objects have the same place in the ranking upon an attribute, the following place will be assigned to the following object.

Variant I

Step 1.

Construct the matrix of places:

$$\text{Place\_oa} = (\text{place\_oa}[i, j])_{\substack{i=\overline{1,\mathbf{i}} \\ j=\overline{1,\mathbf{j}}}}.$$

Step 2.

Construct the matrix:

$$\text{Nocc\_o} = (\text{nocc\_o}[i, \alpha])_{\substack{i=\overline{1,\mathbf{i}} \\ \alpha=\overline{1,\mathbf{i}}}}, \text{nocc\_o}[i, \alpha] =$$

number of occurrences of the object o[i] on place α.

This matrix is determined from the matrix Place_oa. The algorithm starts with Nocc_o matrix with zero elements, and going through the elements of Place_oa, for each $\text{place\_oa}[i, \alpha] = t$ one computes $\text{nocc\_o}[i, \alpha] = \text{nocc\_o}[i, t] + 1$

Step 3.

Compute the evaluation of the objects upon the *m* method:

$$\text{evaluation\_o}[i,m] = \frac{1}{2}\text{nocc\_o}[i,1] + \frac{1}{2^2}\text{nocc\_o}[i,2] + ... + \frac{1}{2^{\mathbf{i}}}\text{nocc\_o}[i, \mathbf{i}],$$

$\forall i = \overline{1, \mathbf{i}}$.

Step 4.

STOP.

Variant II

Step 1.

Construct the matrix of places Place_oa.

Step 2.

Compute for $\forall i = \overline{1, \mathbf{i}}$:

$$\text{evaluation\_o}[i,m] = \sum_{j=1}^{\mathbf{j}} \frac{\text{weight\_a}[j]}{2^{\text{place\_oa}[i, j]}}.$$

Step 3.

STOP.

Nowadays, the Internet is undergoing a fast development of services. *Web enabled optimization* is a new trend in treating Operations Research (OR) problems over the Internet [5 and 6]. Part of this new trend, the OPTCHOICE software is one of the first Internet-based programs designed to describe MADM mathematical models, define assessment / optimal choice / ranking problems on them, and solve these problems in informatics performance conditions [7]. The OPTCHOICE software may be characterized as a pervasive service. Recall that an Internet service is *pervasive* if it is available *to any client, free of charge, anywhere, anytime and without delay* [8]. This software will be used to take over the models built in the following and to solve the associated problems.

3. Models for Acquisitions

The Romanian Air Traffic Services Agency, ROMATSA R.A., provides air traffic services for the aircraft operating GAT (General Air Traffic) flights, under IFR (Instrument Flight Rules) conditions, within the Romanian airspace, as well as within any other airspace allotted to Romania according to international agreements.

In accordance with provided services, ROMATSA has a large number of employees, with a small fluctuation from year to year; the mean number is 1650. All employees have to get to their jobs without delay, the job discipline being the second factor, after the professionalism, assuring the success in this domain of activity.

Some employees use personal means to get in time to their jobs. But for the rest, a special compartment, working with DSNA Bucharest, provides staff transportation on route Bucharest – Baneasa / Otopeni (job points) and return for both kind of shifts (7.00 – 19.00, 19.00 – 7.00) and (8.00 – 16.30). For this, one disposes from a flotilla of Mercedes sprinter shuttle buses with

18+1 seats. These operate on 7 fixed marsh-routes. Sometime the marsh-routes can be modified with the dispatcher approval. A standard marsh-route is presented in the following: Aparatorii Patriei – Cultural – BIG Berceni - Timpuri Noi – Marasesti – Unirii – Intercontinental – Scala – Victoriei – Baneasa (ROMATSA). The loading of a shuttle bus grows with coming near the final destination. It is obvious that the goal of utilizing the shuttle buses at full capacity is far too difficult to accomplish.

Simulated variants with the consideration of involving in the transport planning 5 shuttle buses with 9+1 seats prove to be better than the present transport plan.

Before proceeding with optimal implementation, it is needed a strong decisional support regarding the optimal buying of shuttle buses and the optimal insurance of their maintenance. Hereby, it was necessary to develop three mathematical models for the following acquisition: the shuttle buses and contracting a car repair garage for periodic motor vehicle inspections service (MOT tests) respectively a construction entrepreneur for building an on site work-shop for day-to-day technical revisions / repairs. In the following, one presents all three acquisition models are presented.

3.1 Microbuses Acquisition

The buyer must first submit a purchase bid. In the case of minibuses purchasing, it must indicate, along with the desired models and the volume of the acquisition, the required basic and secondary technical and economic characteristics for the minibuses in question. These are as follows:

Basic technical and economic characteristics:

Makers accepted (Mercedes, Volkswagen, Renault), Volume of purchases (1-5 pieces), Price (20000-35000 €). Transport capacity (9 seats), Seats adaptability (0-1, meaning non-adjustable, respectively adjustable), Maximum speed (160-200 km/h), Diesel consumption (7-9 l/100 km), Fuel tank capacity (70-100 l), Maximum weight (2800 - 3000) kg, Payload (750 - 1000 kg). In order of presentation, the attributes are: exclusion, maximum, minimum, maximum, maximum, maximum, minimum, maximum, minimum, maximum.

Secondary technical and economic characteristics:

Engine power (70-180 HP), Standard equipment (0-1, meaning absence, respectively existence), Optional equipment included (1000 - 3000 €), Duration of lot delivery (20-30 days), Warranty km (0 - 100000 km), Warranty in years (3-6 years), Delivery (0-1, meaning pick-up, respectively delivery). In order of presentation, the attributes are: maximum, maximum, maximum, minimum, maximum, maximum, maximum.

The transportation compartment has recorded a series of statistical data about the commercial behaviour of its suppliers and the operational reliability of their products, so it may now be able to employ these data in the optimization model in the form of attributes hidden from the competitors. Obviously, if upon completion of competition a competitor is not satisfied with the results, these data can be used for clarification. These characteristics of the suppliers' commercial behaviour and the operational reliability of the products purchased from them require some explanation. The attributes refer to suppliers, regardless of the products sold by them. Average unit damages caused by delays in delivery are calculated from 1%, 2%, 3% of the value of delayed shipments and average unit damages caused by undelivered products, from 8% of them. Average unit damages caused by non-compliance with warranty terms are calculated starting from the expenses incurred by the company in order to correct the shortcomings caused by this non-compliance. Average unit damages caused by price differences noted at reception start from the sum of all price differences found in case the product is received, otherwise the situation is treated as non-delivery. Average unit costs for revisions and repairs within the first three years of operation are recorded as they are, considering that, in normal operation, within this three-year period, these costs should be minimum.

Characteristics of the suppliers' commercial behaviour and the operational reliability of the purchased products:

Average unit damage caused by delivery delays of 1 - 10 days, Average unit damage caused by delivery delays of 11 - 20 days, Average unit damage caused by delivery delays of 21 - 30 days, Average unit damage caused by non-delivery, Average unit damages caused by non-compliance with warranty terms, Average unit damages caused by price differences noted at reception, Average unit costs for revisions and repairs in the first year of operation, Average unit costs for revisions and repairs in the second year of operation, Average unit costs for revisions and repairs in the third year of operation.

In this case, all senses of attributes are minimum and can have values between 0 and 5 million lei.

In this tender entered nine suppliers, dealers of Mercedes / VW / Renault:

Mercedes Dealers:

S.C. CASA AUTO SRL**,** S.C. AUTOKLASS BUCURESTI SRL, S.C. RMB INTER AUTO CLUJ SRL.

Volkswagen Dealers:

S.C. MIDOCAR SRL, S.C. CARDINAL MOTORS SRL, S.C. TESS BRASOV SRL.

Renault Dealers:

S.C. IPSO BUCURESTI SRL, S.C. DELTA PLUS TRADING SRL, S.C. AUTO COBALCESCU SRL.

These dealers need to take also into account the offer of the car manufacturers from which they buy the products. This offer is presented below.

For MERCEDES VITO COMBI

General characteristics:

Prices (24500-33800 Euros), Capacity (9 persons), Passenger double bench seat (front row) with three-point seatbelts and head restraints, Triple bench seats for rear compartment (second row) with three-point seatbelts and head restraints, Adjustable seats, Maximum speed (198 km / h), Fuel consumption (8.5 l / 100km), Fuel tank capacity (75 l), Perm. GVW (2940 kg), Payload (975 kg).

Technical Data:

Mercedes-Benz engine type (OM 646 22 LA) (Euro 5, Total displacement 2148 cc, 4 cylinder, 4 valves / cylinder, common rail principle, Electronically controlled direct injection, EU version 4, Gr III, variants of power 95, 116 and 150 HP), Rear-wheel drive, Power-assisted braking system (disc front / rear), Power-assisted steering system, Manual transmission (6+1 speed).

Standard equipment:

ESP (Electronic Stability Program) system, ABS + ASR systems, Driver airbag, Air conditioning, Electrically-operated cabin glasses, Electrically adjustable exterior mirrors, Central locking system with remote control, Sliding door on the right side, Anti-theft electronic engine immobiliser, Radio CD with MP3, Diesel filter with water trap *KL5,

Halogen fog headlights, 6Jx16 steel rims, 195/65-R16 tyres, *Z11 unpaved-road kit.

For VOLKSWAGEN TRANSPORTER COMBI

General characteristics:

Prices (22700-34100 euros), Capacity (9 persons), If is intended mainly for passenger transportation, the type and number of seats can be specified, Two or three passenger bench seats, or folding seats, Tensioning seatbelts, Seats can be removed effortlessly creating a cargo space of up to 6.7 cm, Adjustable seats, Maximum speed (180 km / h), Fuel consumption (7.5 l / 100km), Fuel tank capacity (80 l), Perm. GVW (2840 kg), Payload (860 kg).

Technical Data:

VW diesel engine (Euro 5, four models: 1.9 TDI PD (86 HP) 1.9 TDI PD (105 HP), 2.5 TDI PD (130 HP), 2.5 TDI PD (174 HP), 4 cylinder, 4 valves / cylinder, turbocharged with variable geometry provides the necessary propulsive force, for models up to 140 HP, for the top version - 180 HP model the boost is set in two steps with two-stage turbine), Rear-wheel drive, Power-assisted braking system (disc front / rear), Power-assisted steering system, Automatic transmission (DSG 6+1 speeds, with dual clutch).

Standard equipment:

ESP (Electronic Stability Program) system, ABS + ASR systems, Driver Airbag, Passenger airbag, "Climatronic" air conditioning, Electrically-operated cabin glasses, Electrically adjustable exterior mirrors, Central locking system with remote control, Sliding door on the right side, Anti-theft electronic engine immobiliser, Radio CD with MP3, Halogen fog headlights, Diesel filter with water trap *KL5, Steel rims, All-season tyres 215/60 R17 C 104/102 T, Unpaved-road kit.

For RENAULT MASTER COMBI

General characteristics:

Prices (20400-29500 euros), Capacity (9 persons), Two-seat passenger front bench

with adjustable height head restrains, Triple bench seats for rear compartment (two rows) with and adjustable height head restrains, Removable benches in the rear, Belts in 3 or 2 points depending the position of seats, Adjustable seats, Maximum speed (160 km / h), Fuel consumption (8.7 l / 100km), Fuel tank capacity (100 litres), Perm. GVW (2800 kg), Payload (753) kg,

Technical Data:

Renault diesel type engine (Euro 4 engine, capacity 2464 cc, 4 cylinder, 4 valves / cylinder, Common Rail Turbo Diesel injection type, 74 HP), Front wheel drive, Power-assisted braking system (disc front / rear), Power-assisted steering system, Manual transmission (6 speeds).

Standard equipment:

ESP (Electronic Stability Program) system, ABS + ASR systems, Driver and passenger airbag, Air conditioning, Electrically-operated cabin glasses, Electrically adjustable exterior mirrors, Central locking system with remote control, Sliding door on the right side, Anti-theft electronic engine immobiliser, Radio CD with MP3, Halogen fog headlights, Diesel filter with water trap 4, Steel rims, All-season tyres 195/65 R16, Unpaved-road kit.

The call for tenders of the ROMATSA transportation office, as well as, customised offers of the competitors are described as a MADM mathematical model in Table 1, Table 2 and Table 3 on the following pages. The mathematical model, in its standard formulation, shows very eloquently the problem presented even for people without mathematical knowledge. In this case, the buyer is responsible for the existence of data that describe the object of purchase (the data in the first six rows of the table) and data contained in columns a17 - a25. Every competitor should enter one line, other than the first six, the line representing its offer.

Using OPTCHOICE optimization tool, for Onicescu method, the object o6, i.e. TESS with Volkswagen Transporter Combi, shows to be optimal.

Table 1. "Basic technical-economic characteristics" section

OBJECTS ↓	ATTRIBUTES	a1	a2	a3	a4	a5	a6	a7	a8	a9
	Measure units for attributes →	pieces	€	places	0/1	km/h	l/100km	l	kg	kg
	Attributes' weights →	2%	10%	1%	3%	7%	12%	3%	2%	6%
	Minimal values for attributes →	1	20000	9	0	160	7	70	2800	750
	Maximal values for attributes →	5	35000	9	1	200	9	100	3000	1000
	Optimization sense →	max	min	max	max	max	min	max	min	max
o1	CASA AUTO Mercedes Vito Combi	5	30000	9	1	198	8,5	75	2940	975
o2	AUTOKLASS Mercedes Vito Combi	5	31000	9	1	198	8,5	75	2940	975
o3	RMB INTER AUTO Mercedes Vito Combi	1	28000	9	1	198	8,5	75	2940	975
o4	MIDOCAR Volkswagen Transporter Combi	5	30000	9	1	180	7,5	80	2850	860
o5	CARDINAL MOTORS Volkswagen Transporter Combi	5	32000	9	1	180	7,5	80	2850	860
o6	TESS Volkswagen Transporter Combi	5	27500	9	1	180	7,5	80	2850	860
o7	IPSO Renault Master Combi	3	27000	9	1	160	8,7	100	2800	753
o8	DELTA PLUS TRADING Renault Master Combi	1	25500	9	1	160	8,7	100	2800	753
o9	AUTO COBALCESCU Renault Master Combi	5	29000	9	1	160	8,7	100	2800	753

Table 2. "Secondary technical-economic characteristics" section

OBJECTS ↓	ATTRIBUTES	a10	a11	a12	a13	a14	a15	a16
	Measure units for attributes →	CP	o/1	€	days	km	years	0/1
	Attributes' weights →	10%	5%	7%	3%	3%	3%	2%
	Minimal values for attributes →	70	0	1000	20	0	3	0
	Maximal values for attributes →	180	1	3000	30	200000	6	1
	Optimization sense →	max	max	max	min	max	max	max
o1	CASA AUTO Mercedes Vito Combi	116	1	2000	30	100000	3	0
o2	AUTOKLASS Mercedes Vito Combi	150	1	3000	20	200000	3	0
o3	RMB INTER AUTO Mercedes Vito Combi	116	1	1000	30	100000	3	1
o4	MIDOCAR Volkswagen Transporter Combi	130	1	1500	25	100000	3	0
o5	CARDINAL MOTORS Volkswagen Transporter Combi	174	1	3000	30	150000	3	1
o6	TESS Volkswagen Transporter Combi	174	1	3000	15	200000	3	1
o7	IPSO Renault Master Combi	74	1	1000	20	100000	3	0
o8	DELTA PLUS TRADING Renault Master Combi	74	1	1000	20	100000	3	1
o9	AUTO COBALCESCU Renault Master Combi	74	1	1500	20	100000	3	0

Table 3. "Commercial behavior of dealers and their products reliability" section

OBJECTS ↓	ATTRIBUTES	a17	a18	a19	a20	a21	a22	a23	a24	a25
	Measure units for attributes →	€	€	€	€	€	€	€	€	€
	Attributes' weights →	1%	2%	3%	5%	3%	1%	3%	2%	1%
	Minimal values for attributes →	0	0	0	0	0	0	0	0	0
	Maximal values for attributes →	1000	2000	3000	8000	1000	1000	5000	5500	10000
	Optimization sense →	min	min	min	min	min	min	min	min	min
o1	CASA AUTO Mercedes Vito Combi	825	1400	0	0	325	0	3200	5000	6000
o2	AUTOKLASS Mercedes Vito Combi	420	0	0	0	0	0	3000	4800	5700
o3	RMB INTER AUTO Mercedes Vito Combi	530	220	0	850	430	150	3100	4900	5800
o4	MIDOCAR Volkswagen Transporter Combi	350	0	0	0	200	0	2900	4500	5600
o5	CARDINAL MOTORS Volkswagen Transporter Combi	500	0	0	0	0	0	2700	4400	5500
o6	TESS Volkswagen Transporter Combi	300	0	0	0	0	0	2500	4350	5500
o7	IPSO Renault Master Combi	540	380	0	0	0	140	3300	5200	5900
o8	DELTA PLUS TRADING Renault Master Combi	0	621	0	700	350	200	3450	5100	5800
o9	AUTO COBALCESCU Renault Master Combi	600	0	0	0	160	0	3200	4900	5800

Table 4. Optimal MOT tests service

O B J E C T S ↓	ATTRIBUTES	a1	a2	a3	a4	a5	a6	a7	a8
	Measure units for attributes →	persons	lei	lei	months	lei	lei	lei	0/1
	Attributes' weights →	14%	10%	14%	12%	10%	14%	8%	18%
	Minimal values for attributes →	100	20000	500000	0	0	0	0	0
	Maximal values for attributes →	500	100000	5000000	36	250	125	80	1
	Optimization sense →	max	max	max	min	min	min	min	max
o1	SC AUTO IMPEX SRL	175	85000	2000000	12	200	100	60	0
o2	SC AUTO MOTOR GRUP SRL	300	90000	3500000	16	220	120	75	0
o3	SC M&L SERVICE AUTO IMPEX SRL	290	65000	900000	20	120	125	65	0
o4	SC NEW CAR INTERNATIONAL SRL	450	80000	4000000	24	250	90	80	1
o5	SC MEM SERVICE SRL	350	72500	3250000	12	180	100	70	0
o6	SC AUTO NESTI SERVICE SRL	480	85000	4500000	10	160	120	78	1
o7	SC AUTOMECANICA SCM SRL	400	70000	750000	24	210	95	70	1
o8	SC AUTOTEST 2000 SRL	320	82000	950000	18	200	122	64	0
o9	SC CEFIN ROMANIA SRL	350	92000	4500000	25	240	120	71	1

3.2 Contracting a car repair garage for periodic MOT tests

Due to the fact that the motor vehicle flotilla is large, we observed that the time spent with the periodic motor vehicle inspection is very important in the productive time economy. So far, workers of the motor vehicle flotilla compartment, based on phone reservation, sent vehicles with expired validity for inspection, to any legally authorized car repair garage, which could perform the service at that moment. In this manner, the time spent was found to be very long.

This is why; it is desired to choose from some first-class car repair garages, one that takes exclusivity on MOT tests, based on a contract, making reservations on well-established days, by type of vehicle. This decision is aimed to eliminate waiting times and avoid poor quality car repair garages.

Characteristics of the contractors to be evaluated in this tender are:

Average number of employees (minimum 100 – maximum 500 persons), Capital (minimum 20000 – maximum 100000 lei), Annual turnover (minimum 500000 – maximum 5000000 lei), Average age of equipment (minimum 0 – maximum 36 months), The average tariff / bus (minimum 0 – maximum 250 lei), The average tariff / minibus (minimum 0 – maximum 125 lei), The average tariff / car (minimum 0 – maximum 80 lei), Undertaking repair work upon finding malfunctions (minimum 0 – maximum 1, Boolean expression).

Nine car repair garages, whose id data are given below, have entered the tender:

S.C. AUTO IMPEX SRL, S.C. AUTO MOTOR GRUP SRL, S.C. M&L SERVICE AUTO IMPEX SRL, S.C. NEW CAR INTERNATIONAL SRL, S.C. MEM SERVICE SRL, S.C. AUTO NESTI SERVICE SRL, S.C. AUTOMECANICA SCM SRL, S.C. AUTOTEST 2000 SRL, S.C. CEFIN ROMANIA SRL.

As in the previous case, contracting a garage for performing MOT tests represents actually a MADM mathematical model as shown in Table 4. Because Table 1, 2, 3 and Table 4 are identical in structure, it is obvious that data is related to the business actors, buyers and suppliers, just as described above.

It is known that, by law, the rates for MOT tests are constant for each category of vehicles: buses, minibuses and cars. However if a customer uses the services of a car repair garage in a considerable amount, he can expect a discount. Moreover, the client is more convinced of this discount if the repairs arising upon examination of the vehicle are performed in the same garage and not in a different one.

Intention to perform MOT tests based on reservation, as stipulated in a contract, is welcome by the multitude of repair shops, modern and properly equipped. Therefore the tender has had a large number of competitors.

Using OPTCHOICE optimization tool, for Onicescu method, the object o6, i.e. SC AUTO NESTI SERVICE SRL, shows to be optimal.

3.3 Contracting a construction work

Enlarging the motor vehicle flotilla, brought up the necessity of building an on site work-shop for day-to-day technical revisions / repairs. These revisions and repairs are necessary according to the law in force. This involves execution of construction works that are to be entrusted to a specialized contractor. The revisions / repair work-shop, with a floor area of 120 m², is required to be constructed according to the European standards.

At a simple estimation, the work involves:

500 m³ excavated foundations, 400 m³ concrete casting, 900 m² AACC (Aerated Autoclaved Cellular Concrete) brickwork, 900 m² coatings and finishes, 800 m² Bramac roof tiles, 150 m² IGU (Insulated Glass Units) windows and doors.

The beneficiary is interested in buying all materials needed. The beneficiary is also interested in execution time, which shall be less than 100 days, and warranty of work shall be more than one year. The client has never contracted construction works and, as such, has no information on the seriousness of entrepreneurs, the quality of their work and their reliability. Labour rates on all categories of works mentioned above, are proposed by contractors.

Characteristics of the contractors to be evaluated in this tender are:

Foundation digging rates (maximum 12 Euro/m³), Concrete casting rates (maximum 35 Euro/m³), AACC brickwork rates (maximum 25 Euro/m³), Rates for coatings and finishes (maximum 6 Euro/m²), Rates for Bramac roof-tiling (maximum 6 Euro/m²), Rates for mounting of IGU windows and doors (maximum 8 Euro/m²), Execution time-span (minimum 30 – maximum 100 days), Warranty (minimum 12 – maximum 60 months), The price of the project (minimum 1500 – maximum 3000 Euro).

Five construction companies whose identifiers are given below have entered the tender:

S.C. TERRA ELYMAR SRL, S.C. CONFMET CONSTRUCTII CLUJ SRL, S.C. CONSTRUCT BN 2001 SRL, S.C. A&N DESIGN CONF SRL, S.C. ARCHETON SRL.

Observations on the mathematical model given in Table 5, compared with previous ones made in paragraphs 3.1 and 3.2, *mutatis mutandis*, are valid in this case too.

Using OPTCHOICE optimization tool, for Onicescu method, the object o1, i.e. S.C. TERRA ELYMAR SRL, shows to be optimal.

4. Conclusions

In order to test the proper functioning of the variants of the MADM model, there have been conducted computer experiments. These have satisfied the decision makers. A decisive direction in the successful use of this model is resorting to OPTCHOICE, the pervasive service for MADM modelling and optimal choice problem solving.

Data presented in this work are not the actual data from ROMATSA but are close enough to be useful for readers interested in optimizing the acquisition process.

Table 5. Optimal construction works contract

	ATTRIBUTES	a1	a2	a3	a4	a5	a6	a7	a8	a9
O B J E C T S ↓	Measure units for attributes →	€/m³	€/m³	€/m³	€/m²	€/m²	€/m²	days	months	€
	Attributes' weights →	14%	14%	11%	11%	13%	9%	8%	8%	12%
	Minimal values for attributes →	0	0	0	0	0	0	30	12	1500
	Maximal values for attributes →	12	35	25	6	6	8	100	60	3000
	Optimization sense →	min	min	min	min	min	min	min	max	min
o1	S.C. TERRA ELYMAR S.R.L.	9.50	29	22	4	4.50	7	85	55	2500
o2	S.C. CONFMET CONSTRUCTII CLUJ S.R.L.	12	31	23.25	6	5.25	6.50	90	50	3000
o3	S.C. CONSTRUCT BN 2001 S.R.L.	11.50	32.25	25	5	5	6.25	75	60	2500
o4	S.C. A&N DESIGN CONF S.R.L.	10	34	23	5.50	4.75	7.50	95	45	2800
o5	S.C ARCHETON S.R.L.	11	34.50	24.50	4.50	4	7	90	50	2700

Our intention was mainly to demonstrate the ability of this model to function for products,

services and works. It is common knowledge that, usually, the literature mainly refers to the acquisition of products and when taking into accounts the services / works; this is usually done by using other mathematical models. This unitary treatment of these acquisitions presented in the paper is an important feature of the MADM model.

Accurate modelling and IT performance determine the existence of a modern decision support. This kind of tools leads to optimal decision making. For a large number of enterprises, optimal decision making, at different level of decision, is nowadays a common activity.

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