THE ANALYTICAL HIERARCHY PROCESS FOR E-SCOUTING: DECISION-MAKING FOR INDUSTRIAL PROCUREMENT PROCESS

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ABSTRACT

Given the state of the art in ICT applied to procurement, the model for generic supply process cannot be a reference standard because it was generated at a time when ICT was at a totally different level in terms of technology and conceptual models.
This work partially re-engineers the generic supply with the aim of making the choice of a supply alternative (Product/Service/Supplier) more rational, efficient, effective and consistent with the evaluation criteria in a world of web solutions.
In order to save cost and time an e-scouting process has been designed based on a two step application of Analytic Hierarchy Process. The defined methodology was then industrially implemented to support the decision-making in purchasing of a CNC Work Centre.

Keywords: Multi-Criteria Decision Making, Analytic Hierarchy Process, e-procurement.

1. Introduction

The hyper-competitive markets induced companies to focus on those functional organisational areas where cost margins can be reduced converting – where possible – those areas from 'Costing Centres' into 'Savings Centres'. The functional area responsible for the acquisition of those goods or services required for the production process is enjoying great strategic expansion: acquisitions represent about 70% of the cost of sales and the widespread System Buying is likely to further increase over System Making in the next few years. This is why some companies have converted their 'Acquisitions offices' into 'Strategic departments for resource acquisition' (Kotler, and Keller, 2006). 'Buygrid' (Robinson et al., 1967) was the first conceptual model of industrial supply: it identifies correlated phases and classes of acquisition. A version upgraded by Kotler (Kotler, and Keller, 2006) highlighted supply risk correlating it to the number of acquisition phases per acquisition class: new task, modified re-buy, straight re-buy.
In the early 70s, Webster and Wind classified supply as a proper decision-making process within organisations. Furthermore, the authors defined the first standard model of 'Buying Centre' as well as the

roles and activities of its every component in the decision-making process (Webster, and Wind 1972). Fundamental analyses of the generic industrial sector carried out by Porter in the early 80s (Porter, 1980) identified suppliers as one of five forces capable of influencing profitability within a sector.
In the first half of the 80s, Kraljic (Kraljic, 1983) created a supply strategy with two factors aimed at reducing 'Supply Risk': acquisition importance, supply market complexity. Plotting these two factors in a graphic array (Kraljic matrix) highlights four item categories each of which associated to a suitable type of supply management.
Confirming the strategic value which has been acquired by supply at every level of business, the structural model for creating 'Value chains' (Porter, 1985), the brainchild of Porter in 1985 and universally recognised in the managerial sciences, identifies procurement as a support activity in the early phases of value creation as well as the source of competitive advantage for a business.
Optimising supply is an indispensible strategy for obtaining competitive advantage for a business.
The introduction of ICT into the supply chain or the move to e-procurement has not caused any procedural upheaval for Robinson, Faris and Wind's 'Buygrid' but rather an increase in efficiency from digitalizing the process with the knock-on of shortening operations to the advantage of 'Strategic Purchasing' (Monczka et al., 2008).
Furthermore, the literature highlights the absence of a universal model of e-procurement or rather the absence of standardized models for applying ICT to e-procurement (Garrido-Samaniego et al., 2010).
The 'Buygrid' model which concerns supply in general and currently state of the art ICT applied to e-procurement cannot also cover the role of reference standard because it was developed at a time when ICT was considerably different to current technology and concepts.
So, we have partially re-engineered generic supply with the aim of making the choice of a supply alternative (Product/Service/Supplier) more rational, efficient, effective and consistent with the evaluation criteria in a world of web solutions.
To maximize buying power and minimize choice time a process of e-scouting has been designed based on Multi-Criteria Decision Making – Analytic Hierarchy Process, which was then implemented industrially to support the decision-making in purchasing of a CNC Work Centre. Not unequivocally defined in literature, 'e-scouting' is that collection of activities which are a part of e-procurement by means of which the business identifies and evaluates supply alternatives (Product/Service/Supplier) in a world of web solutions.

2. Methodology

2.1 The Analytic Hierarchy Process for ranking a fixed number of alternatives

The Analytic Hierarchy Process (AHP), a Multi-Criteria Decision Making technique developed by Saaty at the end of the 70s makes criteria-based decision-making feasible by transforming even subjective decision making into objective numerical ones. By means of pair comparisons, AHP works by prioritising alternatives and the verification criteria used to select alternatives. The technique leads to 'Rational decisions' according to the following definition: "a rational decision is one which best fulfils the greatest number of objectives of the decision-maker".
The first step in applying AHP is defining a hierarchy of at least three levels:

- Level 1: **1** general objective of evaluation;
- Level 2: **r** evaluation criteria;
- Level 3: **s** alternative objects of evaluation.

The Figure 1 highlights the three-levels AHP hierarchy and the connections between objectives, criteria and alternatives.

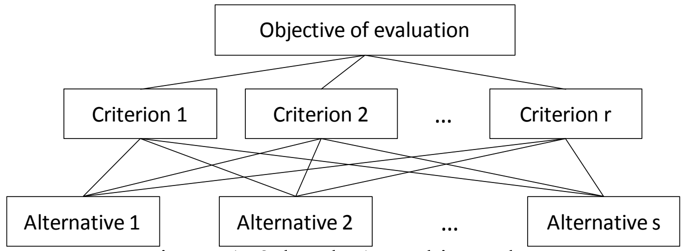

Figure 1. 3-levels AHP hierarchy.

The next step in applying AHP is to construct matrices of pair comparisons in which all the components subordinate to one single hierarchy component are compared in pairs. Therefore, these are constructed:

- **1** pair comparison matrix between **r** criteria;
- **r** pair comparison matrices between **s** alternatives.

For the calculation of the matrices and of consistency ratio (CR) please refer to (Saaty, and Vargas, 2001). The last step for ranking a definite number (**s**) of alternatives is defining the global weights of the alternatives by applying the principle of hierarchical composition to calculate the importance of each element in relation to the main objective: proceeding from top to bottom, the local weights of all elements of the hierarchy are thus gradually evolved into global weights. The global weights help calculate an order of preference: the more preferable the alternative, the greater its global weight. The global weights of the elements located at the bottom of the hierarchy represent the main result of the evaluation.

2.2 The Analytic Hierarchy Process for ranking an indefinite number of alternatives

The Analytic Hierarchy Process can rank an indefinite number of alternatives once certain modifications are made. Modified AHP needs a 4-levels hierarchy (see Figure 2).

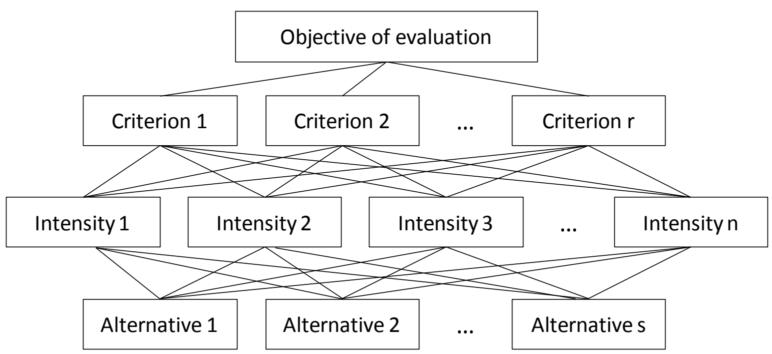

Figure 2. 4-levels AHP hierarchy.

As shown in Figure 2 the 4-levels are:

- Level 1: **1** general aim of the evaluation;
- Level 2: **r** evaluation criteria;
- Level 3: **n** criteria intensity;
- Level 4: **s** evaluation alternatives.

Hierarchy levels 2 and 3 are used to calculate the local weights with Saaty's semantic scale.
The last step in ranking an indefinite number of alternatives is to define the global weight of alternative i-th by applying the principle of hierarchic composition. By iterating the final step (above) with an indefinite number of alternatives we obtain vector s x 1 of the global weights of s alternatives.
So the two described AHP methodologies for ranking an indefinite number of alternatives and for ranking a fixed number of alternatives were applied in two steps, as shown in Figure 3.

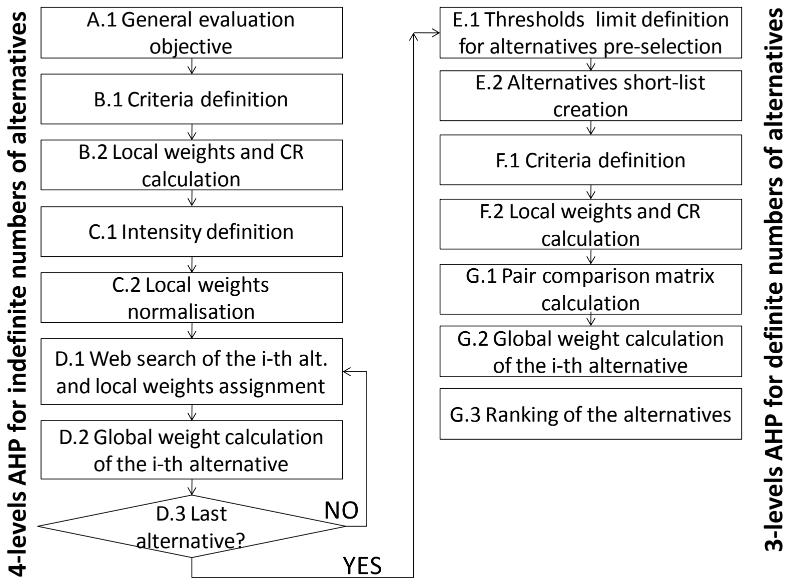

Figure 3. The two steps for AHP application.

3. Case of study

The subject of this study, e-scouting, is applicable to 'New task' supply alternatives via internet.
Strong market competition, the widely spread web tools for e-procurement and in particular e-catalogs containing all the technico-economic data about supply alternatives make buying a 'New Task' feasible by means of e-scouting which minimizes supply costs and maximizes its value.
All the e-scouting activities for each AHP level are described below, referring to Figure 3.

3.1 General evaluation objective (A)

Industrial decision-makers have to buy a computer numerically controlled work centre (CNC) specifying the supply constraints (Five interpolated axes; Axes travel: X ≥ 1800 mm, Y ≥ 650 mm, Z ≥ 650 mm).

3.2 Criteria definition, local weights and CR calculation (B)

The six evaluation criteria defined by the industrial decision-maker are reported in Table 1. Table 1 also shows the local weights calculated for the six criteria. The corresponding value of CR equals 0.16.

Table 1 Local weights of evaluation criteria

r	Criteria	Description	Local weights
1	Aesthetics	measured on 3 quality and satisfaction levels	1.73%
2	Robustness	measured as a maximum weight supported by the table [kg]	31.06%
3	Flexibility	measured on 3 quality levels and as a function of system type	43.54%
4	Rotation velocity	Angular speed [rpm]	9.45%
5	Forward velocity	Translational speed [m/min]	9.45%
6	Buffer dimension	Store capacity, measured in tool store places	4.77%

3.3 Intensity definition and local weights normalisation (C)

There are 9 intensities of evaluation criteria (from BB to HH) associated to the intervals and values of the target data as in Table 2. Table 2 also shows normalised vector **9** x **1**of the local weights for the nine intensities obtained weighing intensity of the criteria for evaluating the supply commodity or defining the comparison matrix of pairs of intensity of the criteria.

Table 2 Intensity – interval association and target data values.

n	Intensity	Aes [ ]	Rob [kg]	Flex [ ]	Rot. Vel. [rpm]	Fwd Vel. [m/min]	Buffer [tool no.]	Normalised local weight
1	HH	Hi	>1300	Head-Table	>24000	>34	>24	1.000
2	HM		[1200, 1300[		[22000, 24000[	[32, 34[	[22, 24[	0.712
3	HB		[1100, 1200[		[18000, 20000[	[30, 32[	[20, 22[	0.498
4	MH		[1000, 1100[		[20000, 22000[	[28, 30[	[18, 20[	0.344
5	MM	Ave	[900, 1000[	Head-Head	[16000, 18000[	[26, 28[	[16, 18[	0.237
6	MB		[800, 900[		[18000, 20000[	[24, 26[	[14, 16[	0.162
7	BH		[700, 800[		[14000, 16000[	[22, 24[	[12, 14[	0.112
8	BM		[600, 700[		[12000, 14000[	[20, 22[	[10, 12[	0.079
9	BB	Lo	<600	Table-Table	<10000	<20	<10	0.059

3.4 Web search of the alternatives and weights assignment (D)

The target data of the i-th alternative related to each criteria was extracted from the web and weighed through the intensity factor associated to each criteria. The results of these calculations are shown in Table 3 only for three of the twenty-one analyzed alternatives.

Table 3 Association of alternative Target Data to intensity and Normalised global weights.

s	Alt	Aes [ ]	Rob [kg]	Flex [ ]	Rot. Vel. [rpm]	Fwd Vel. [m/min]	Buffer [tool no.]	Normalised global weight
1	a	0.237	1.000	0.237	0.498	0.059	1.000	0.518
2	b	0.237	1.000	1.000	0.237	0.112	0.237	0.794
…	…	…	…	…	…	…	…	…
21	z	1.000	0.059	0.059	0.059	0.059	0.498	0.096

The steps D.1 and D.2 (in Figure 3 can be iterated in order to assess an indefinite number of alternatives and ranking it: a supply commodity will be more preferable the greater its global weight (see Table 4).

3.5 Thresholds limit definition for alternatives pre-selection and alternatives short-list creation (E)

This is the first step for 3-level AHP application for a fixed number of alternatives.
A threshold value is defined as 0.700 and the pre-selected alternatives are only the six reported in Table 4.

Table 4 Local and global weight for the ranking of selected alternatives

Criteria	Aes [ ]	Rob [kg]	Flex [ ]	Rot. Vel. [rpm]	Fwd Vel. [m/min]	Buffer [tool no.]	Annual Cost [€/a]	Global weight
b	0.084	0.292	0.167	0.205	0.139	0.102	0.169	20.16%
c	0.392	0.175	0.167	0.205	0.279	0.152	0.179	18.75%
l	0.025	0.175	0.167	0.308	0.177	0.127	0.122	17.88%
d	0.115	0.164	0.167	0.082	0.139	0.305	0.160	15.93%
f	0.064	0.088	0.167	0.123	0.195	0.152	0.189	14.03%
v	0.320	0.106	0.167	0.077	0.070	0.162	0.181	13.25%
Criteria Weight	1.46%	29.98%	40.22%	9.99%	9.99%	4.18%	4.18%	100.00%

3.6 Criteria definition, local weights and CR calculation (F)

The total annual cost criteria (€/a), including amortization of acquisition cost and operating costs, is added to the previously identified criteria.

The result is the vector of the local weights of the seven criteria shown in the second row of Table 4, to which there is a corresponding CR value of 0.185.

3.7 Global weight calculation of the i-th alternative and final ranking of the alternatives (G)

In Table 4 were also reported the global weight vector obtained multiplying the matrix of local weights of the pre-selected alternatives and the vector of local weights of evaluation criteria. The most preferable alternatives are ranked in Table 4.

4. Conclusions

In production plants with widespread ICT at each phase of the 'Value chain', the absence of standardised models of e-procurement has led to partially re-engineering the supply process with the aim of choose among the lot of supply alternatives (Product/Service/Supplier) in a more rational and efficient manner, in line with identified evaluation criteria. The high number of supply alternatives (available on web) and of evaluation criteria suggested to design an e-scouting procedure based on a Multi Criteria Decision Making (MCDM) method. In particular, AHP was used because it allows the comparison among an indefinite number of alternatives (as those avalable on the web) or among a fixed number of alternatives (as those pre-selected by decision makers).
The e-scouting software was implemented on a spreadsheet to support the industry experts.

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