OPTIMAL ALLOCATION OF ECONOMIC RESOURCES USING THE AHP ABSOLUTE MODEL

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ABSTRACT
One often wonders why more people in organizations do not rush today to use a formal decision-making approach to make their complex decisions. A strange thing about people is that they value money and other valuable resources over their own loosely defined and not well-organized subjective value systems. This paper places special emphasis on the measurement of intangible criteria and on their incorporation into the allocation process through a proper decision making approach. The purpose of decision-making is to help people make decisions according to their own understanding. In this paper, a well know decision-making method, the Analytic Hierarchy Process (AHP) is applied to identify a quality model to evaluate Italian racecourses performances based upon the criteria: Quality organization of Racing, Infrastructure and Equipment, Attractiveness and Management Skill. The main conclusion is that the AHP model adopted can manage all the information of the real-world problem.

Keywords: Analytic Hierarchy Process, DSS, Performances, Racecourse

1. INTRODUCTION

In today's global economy, characterized by a dynamic and volatile environment, many researchers stress the importance of international location factors (Badri and Davis, 1995). Some of the issues associated with global expansion and location include multiple political, economic, legal, social, and cultural environments. Location-allocation decisions involve a substantial capital investment and result in long-term constraints on production and distribution of goods (Strebel, 2003; Seeley, 2002). These problems are complex and, like most real world problems depend upon a number of tangible and intangible factors which are unique to each problem (De Felice and Petrillo, 2010 a). The complexity stems from a multitude of quantitative and qualitative factors influencing location choices as well as the intrinsic difficulty of making numerous trade-offs among those factors (De Felice and Petrillo, 2012). One analytical approach often suggested for solving such a complex problem is the Analytic Hierarchy Process (AHP) introduced by Saaty (Saaty, 1980). The AHP enables the decision maker to structure a complex problem in the form of a simple hierarchy and to evaluate a large number of quantitative and qualitative factors in a systematic manner under conflicting multiple criteria. It is developed and designed to solve complex problems involving multiple criteria. It is a highly flexible decision methodology that can be applied in a wide variety of situations (De Felice, Petrillo and Silvestri, 2012). There are two types of measurement involved in the AHP, *absolute* and *relative*. The first requires a standard with which to compare elements, but mostly alternatives at the bottom of the hierarchy. The process leads to absolute preservation in the rank of the alternatives no matter how many are introduced. The second is based on paired comparisons among the elements of a set with respect to a common attribute. This process is essential for comparing intangible attributes for which there are no agreed upon measures. At the level of alternatives new elements (i.e. alternatives) do introduce new information generated by the changing number in the set and by their measurement which essentially rescales the criteria and hence can lead to reversals of previous rank orders. Absolute measurement is used on standardized problems whereas relative measurement is used in new learning situations (Saaty, 2005). Absolute method is typically used in a decision situation, which involve selecting one (or more) decision alternatives from several "candidate" decision alternatives on the basis of multiple decision criteria of a competing or conflicting nature (McCarthy, 2000). In this paper, we have developed a case study on racecourse performance appraisal *using AHP absolute model*. Though AHP has been applied in numerous real settings, but there isn't evidence that AHP has been applied in racecourse performance evaluation (De Felice and Petrillo, 2010 b). This paper attempts to fill up the gap. The aim of our paper is to explain, through a real case study, the uses of multi-criteria prioritization in resource allocation, and in particular the use of absolute measurement in the optimal assignment of economic resources.

2. THE PROGRESSION OF THE PLANNING MODEL

A feature of absolute measurement AHP is that the scale for each lowest level criterion consists of indicator categories (e.g. A, B, C, etc.). Thus, the alternatives

consist of the these categories or grades. Absolute measurement AHP requires a pairwise comparison procedure between indicator categories (for each lowest level criterion) to establish the relative weights for these categories using eigenvector approach (Park and Lim, 1999). In other words in absolute measurement the properties of an element are compared or "rated" against a standard (Leskinen, 2000). In this method an element is compared against an ideal property; i.e. a "memory" of that property (Saaty *et. al*, 2003). Generally, only the final alternatives of choice are measured absolutely. For example, students applying for admission are rated on grades, letters of recommendation and standardized test scores. A student's final rating is the weighted sum of the ratings on the various criteria (De Felice and Petrillo, 2011).
Here below and in Figure 1 are the steps of absolute measurement process adopted:

- **Step 1:** Identify the criteria, subcriteria and alternatives (to be evaluated) for evaluation and put them into the AHP hierarchy.
- **Step 2:** Calculate the weights of the decision criteria and subcriteria by the relative measurement of AHP, i.e., construct the pairwise comparison matrix for all the criteria and compute the normalized principal right eigenvector of the matrix. This vector gives the weights of the criteria.
- **Step 3:** Divide each subcriteria into several intensities or grades. Set priorities on the intensities by comparing them pairwise under each subcriteria. Multiply these priorities by the priority of the parent subcriteria.
- **Step 4:** Take one alternative at a time and measure its performance intensity under each subcriteria.

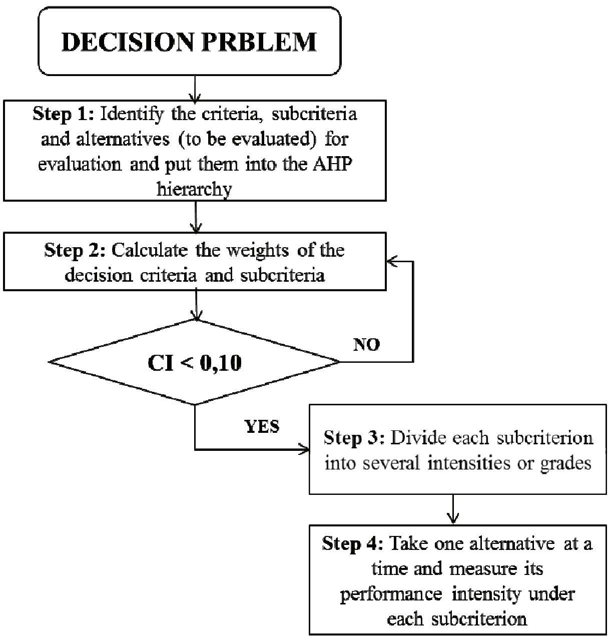

Figure 1: Methodological approach

3. THE CASE STUDY

In this paragraph we will analyze the AHP model adopted in order to rank racecourses quality performance.

3.1. STEP 1: Identify the criteria, subcriteria and alternatives

We developed the following AHP Model to determine the criteria and subcriteria weights. In figure 1 is shown AHP Model (see Appendix A).

Regards the alternatives we selected 40 different Italian racecourses.

Here below in the following tables (Table from 1 to 5) is the description of criteria and subcriteria.

Table 1: Criteria - Description

Criteria	Description
C1	The ability to organize spectacular and corrected races.
C2	The availability of appropriate facilities and equipment maintained in good condition
C3	The ability to attract and retain customers
C4	The adoption of policies that introduce the culture associated with the horse culture of corporate values (integrity, ethics, competitiveness, investment)

Table 2: SubCriteria C1 - Description

SubCriteria C1	Description
C1.1	Evaluation of the ability to organize and plan races with a reasonable number of participants by offering an enjoyable spectacle
C1.1	Assessment of the ability to encourage the creation of a field starters balanced in order to ensure an enjoyable and profitable spectacle from the point of view of the bets
C1.3	Technical evaluation of horses winning
C1.4	Evaluating the timeliness of races (deadlines and procedures, in the absence of accidents)
C1.5	Disciplinary reports for each racecourse

Table 3: SubCriteria C2 - Description

SubCriteria C2	Description
C2.1	Areas dedicated to horse racing (sum of all areas of race tracks); parameters to consider are the type (sand, grass, synthetic), size (length x width)
C2.2	Area devoted to public aims such as parterres, bars, parks, restaurants, or other structures with free access for public
C2.3	Structure of the relevance of the hippodrome, independent and external to it, continuously and exclusively dedicated to training, including trails and picnic areas (parameter indicative of the right size: relationship to runways. / N.box)
C2.4	Areas which include services for owners / operators such as surgery, dining room, lunchroom, etc.. Areas which include services such as veterinary clinic for horses, garage available, etc.
C2.5	Number and type of racecourse facilities support activities, such as runway lighting system, timekeeping system, TV system
C2.6	Indicator characterizing the value of the plant

Table 4: SubCriteria C3 - Description

SubCriteria C3	Description
C3.1	Evaluation of the ability to make equestrian events and horse shows, contemporary and otherwise, who play a role call for the competitive event. The initiatives should be compatible and complementary to the races, including through the promotion of culture horseracing courses (promotion)
C3.2	Evaluation of plant capacity to attract bettors
C3.3	Evaluation of attractiveness on the betting market
C3.4	Number and types of services appropriate and welcoming to the public
C3.5	Importance of the plant economy tradition of horse racing
C3.6	Evaluation of the ability of attracting the public

Table 5: SubCriteria C4 - Description

SubCriteria C4	Description
C4.1	Certification of financial statements
C4.2	Achievement of certification by recognized organizations: Quality ISO 9000, ISO 14001 Environment, OHSAS 18001 Safety
C4.3	Production of a document demonstration of the ability to generate social values in the local context, linked to the economic value of the (animal protection, employment, etc.)
C4.4	Assessment of financial strength
C4.5	Statement of annual expenditure
C4.6	Company’s ability to have other forms of financing including sponsorship and related activities

3.2. STEP 2: Calculate the weights of the decision criteria and subcriteria

In this phase were developed pairwise comparison matrices to determine the criteria and subcriteria weights. In Appendix B are shown the pairwise comparison matrices (figure 2, 3, 4, 5 and 6). In the AHP paired comparisons are made with judgments using numerical values taken from the AHP absolute fundamental scale of 1-9. A scale of relative values is derived from all these paired comparisons and it also belongs to an absolute scale that is invariant under the identity transformation like the system of real numbers . After all pairwise comparison the consistency index (CI) of the derived weights was calculated by Equation (1):

$$CI \frac{\lambda_{max} - n}{n-1} \quad (1)$$

In general, if CI is less than 0.10, satisfaction of judgments may be derived. Here below in the following figures (figure 7, 8, 9, 10 and 11) are shown the weights derived from pairwise comparison for each criteria and subcriteria.

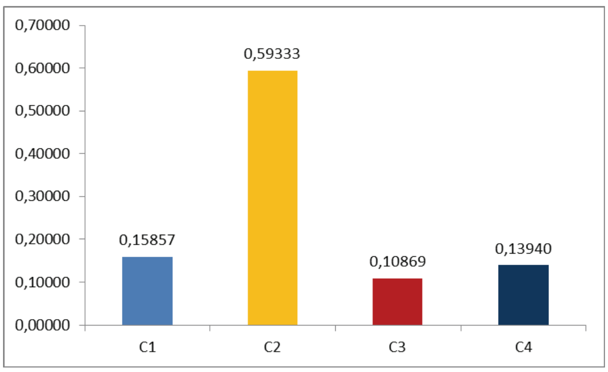

Figure 7: Weights for each criteria

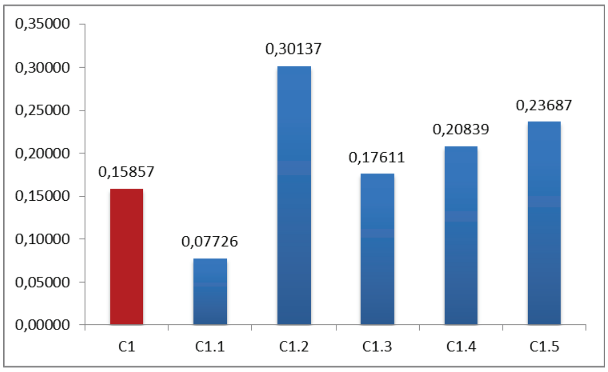

Figure 8: Weights for subcriteria C1

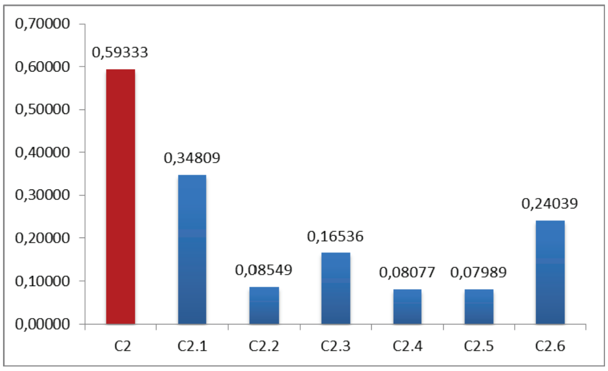

Figure 9: Weights for subcriteria C2

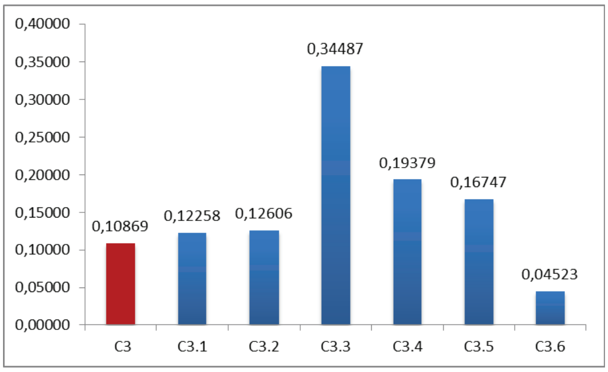

Figure 10: Weights for subcriteria C3

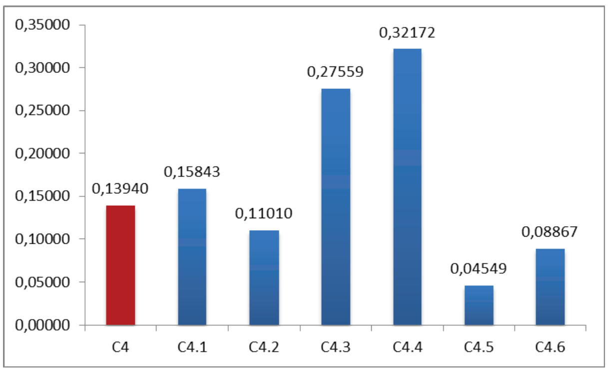

Figure 11: Weights for subcriteria C4

In appendix C are show weights for all criteria and subcriteria.

3.3. STEP 3: Divide each subcriteria into several intensities or grades

In this step each subcriteria are further subdivided into a level for intensities. Each criterion has ratings listed under it. An example would be to take a criterion of cost and list under it "very high", "high", "average", and "low". These are ratings that are then prioritized to determine their relative importance. The type and number of ratings for each criterion may be different. An intensity is a range of variation of a criterion that enables one to distinguish the quality of an alternative for that criterion. An intensity may be expressed as a numerical range of values if the criterion is measurable or in qualitative terms (Saaty, et al. 2007; Rafikul and Mohd Rasad, 2005).

For example, the evaluation criteria for " C1.1 - Average of the horses left for race" have the following intensities (see Table 6):

Table 6: Example of criteria intensity

Score	from	to
1	0	<7
3	7	<8
5	8	<10
7	10	<12
9	12	up

We set priorities for the criteria by comparing them in pairs. We then pairwise compare the intensities according to priority with respect to their parent criterion C1 (Table 7). The priorities of the intensities are divided by the largest intensity for each criterion and subcriteria to put it in the ideal mode

Table 7: Comparing Intensity of C1.1

	0-<7	7-<8	8-<10	10-<12	12-up	priority
0-<7	1	3	5	7	9	0,493
7-<8	1/3	1	3	5	7	0,255
8-<10	1/5	1/3	1	9	7	0,167
10-<12	1/7	1/5	1/9	1	9	0,061
12-up	1/9	1/7	1/7	1/9	1	0,024

Table 7 gives a comparison of the intensities for C1.1. The other intensities are similarly compared.

Table 8: The ideal intensity Mode

	Priorities Weighted by C1 and C1.1	Divide by largest value
0-<7	(*) 0,006038	0,495597
7-<8	0,012184	1
8-<10	0,004659	0,382407
10-<12	0,002032	0,166781
12-up	0,000897	0,073596
(*) 0,493x 0.158x0.0772 =0,006038		

Table 8 gives the ideal intensity mode for C1 and C1.1. The other ideal intensities mode are similarly obtained.

3.4. STEP 4: Take one alternative at a time and measure its performance intensity under each subcriteria

In this step, finally, we rate each alternatives by assigning the intensity rating that applies to them under each criterion (Table 9). The scores of these intensities are each weighted by the priority of its criterion and summed to derive a total ratio scale score for the alternative.

Table 9: Ranking

Name	Ideals	Normals
AB	0.501236	0.023535
AC	0.465246	0.021845
AD	0.728787	0.034220
AE	0.255768	0.012009
AF	0.463271	0.021753
AG	0.429542	0.020169
AH	0.634037	0.029771
AI	0.490323	0.023023
AJ	0.404723	0.019003
AK	0.456050	0.021414
AL	0.187590	0.008808
AM	0.375334	0.017624
AN	0.524765	0.024640
AO	0.560826	0.026333
AP	0.601429	0.028240
AQ	0.604732	0.028395
AR	0.785092	0.036863
AS	1.000.000	0.046954
AT	0.610738	0.028677
AU	0.462112	0.021698
AV	0.603960	0.028359
AW	0.520404	0.024435
AX	0.648255	0.030438
AZ	0.556822	0.026145
BA	0.444911	0.020891
BB	0.909919	0.042725
BC	0.382625	0.017966
BD	0.241810	0.011354
BE	0.879245	0.041284
BF	0.624901	0.029342
BG	0.684889	0.032159
BH	0.460543	0.021625
BI	0.501866	0.023565
BJ	0.444563	0.020874
BK	0.460436	0.021619
BL	0.252033	0.011834
BM	0.499912	0.023473
TRT	0.459184	0.021561
TVO	0.569757	0.026753
VAS	0.609651	0.028626

4. CONCLUSIONS

Economic allocation resources is more complex and risky due to uncertainty and volatility of international environments. The global location-allocation decision process involves qualitative as well as quantitative factors. The decision-makers can no longer ignore the influence of highly judgmental and sensitive factors such as the political situation, global competition and survival, government regulations, and economic factors. In this context our aim is to develop a flexible decision model in order to cope with the changes.
On the other hand the use the use of absolute (rather than relative) scales for scoring the alternatives provides the following advantages:

- The addition of a new alternative doesn't require new pairwise comparisons with all other alternatives;
- There is no potential for rank reversal with addition or deletion of the alternative;
- As an alternative is added or deleted or as its score changes, the scores of all other alternatives remain the same.

We can conclude that this approach can be used whenever it is possible to set priorities for intensities of criteria; people can usually do this when they have sufficient experience with given operation. In addition, one can use this approach to rate many alternatives but then choose the top few and perform paired comparisons on them directly with respect to the criteria by deleting the intensities from hierarchy.

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AUTHORS BIOGRAPHY

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The scientific activity developed through studies and researches on problems concerning industrial plant engineering. Such activity ranges over all fields from improvement of quality in productive processes to the simulation of industrial plants, from support multicriteria techniques to decisions (Analytic Hierarchy Process, Analytic Network Process), to RAMS Analysis and Human Reliability Analysis. The main university courses in which he is involved are: Safety of Industrial Plants, Industrial Production Management, Industrial Simulation, Human Reliability Analysis.
He is author of several books, and papers in international journals and conference proceedings. He has also been a member of several editorial boards. In addition he is founder of the AHP Academy - International Association for the promotion of multi-criteria decision making methods.

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APPENDIX A

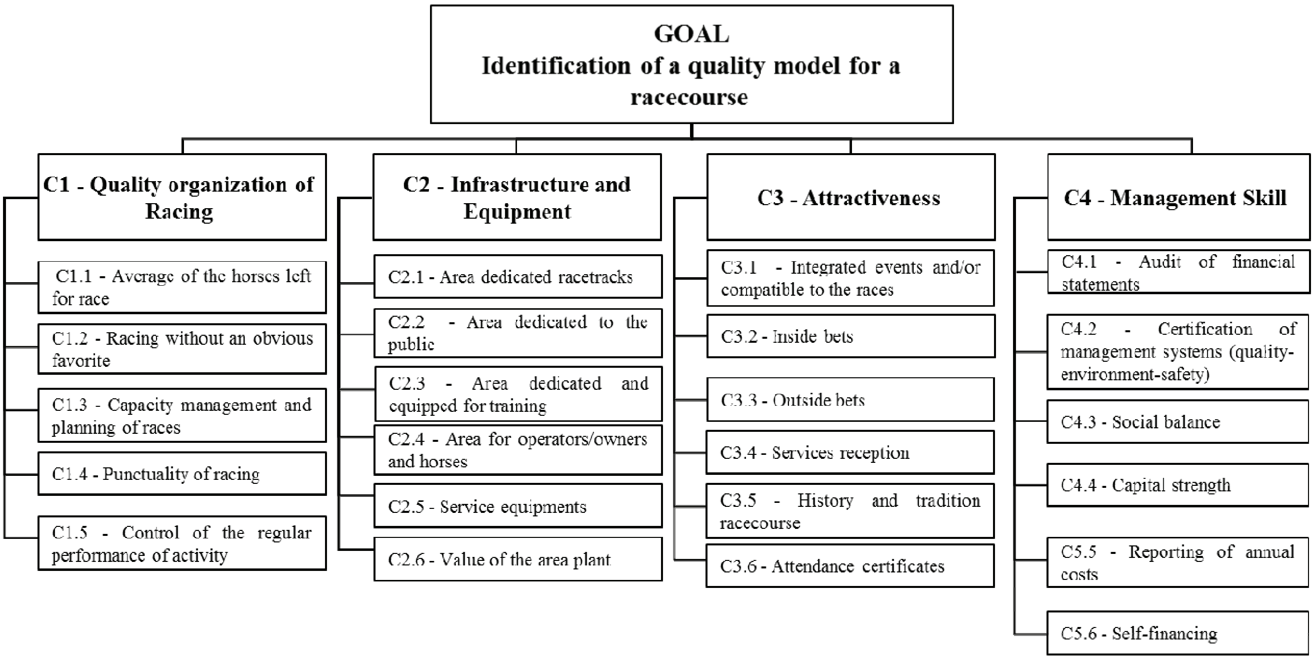

Figure 1: AHP Model

APPENDIX B

C1	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	**C1**
C1	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	**C1**
C1	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	**C1**
C2	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	**C2**
C2	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	**C2**
C3	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C3**
CI = 0.07193																		

Figure 2: Criteria - Pairwise comparision

C1.1	9	8	7	6	5	4	3	2	1	2	3	4	5	**6**	7	8	9	**C1.2**
C1.1	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C1.3**
C1.1	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C1.4**
C1.1	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C1.5**
C1.2	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	**C1.3**
C1.2	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	**C1.4**
C1.2	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	**C1.5**
C1.3	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C1.4**
C1.3	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C1.5**
C1.4	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	**C1.5**
CI = 0.06506																		

Figure 3: Subcriteria C1 - Pairwise comparision

C2.1	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C2.2**
C2.1	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C2.3**
C2.1	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C2.4**
C2.1	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C2.5**
C2.1	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C2.6**
C2.2	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C2.3**
C2.2	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	**C2.4**
C2.2	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C2.5**
C2.2	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C2.6**
C2.3	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C2.4**
C2.3	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	**C2.5**
C2.3	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C2.6**
C2.4	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	**C2.5**
C2.4	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C2.6**
C2.5	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C2.6**
CI = 0.09894																		

Figure 4: Subcriteria C2 - Pairwise comparision

C3.1	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C3.2**
C3.1	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C3.3**
C3.1	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	**C3.4**
C3.1	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	**C3.5**
C3.1	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	**C3.6**
C3.2	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C3.3**
C3.2	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C3.4**
C3.2	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C3.5**
C3.2	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	**C3.6**
C3.3	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C3.4**
C3.3	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C3.5**
C3.3	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	**C3.6**
C4.3	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	**C3.5**
C4.3	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C3.6**
C3.5	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	**C3.6**
CI = 0.09694																		

Figure 5: Subcriteria C3 - Pairwise comparision

C4.1	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C4.2**
C4.1	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C4.3**
C4.1	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C4.4**
C4.1	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	**C4.5**
C4.1	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	**C4.6**
C4.2	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	**C4.3**
C4.2	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C4.4**
C4.2	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C4.5**
C4.2	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C4.6**
C4.3	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	**C4.4**
C4.3	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	**C4.5**
C4.3	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	**C4.6**
C4.4	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	**C4.5**
C4.4	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	**C4.6**
C4.5	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	**C4.6**
CI = 0.09755																		

Figure 6: Subcriteria C4 - Pairwise comparision

APPENDIX C

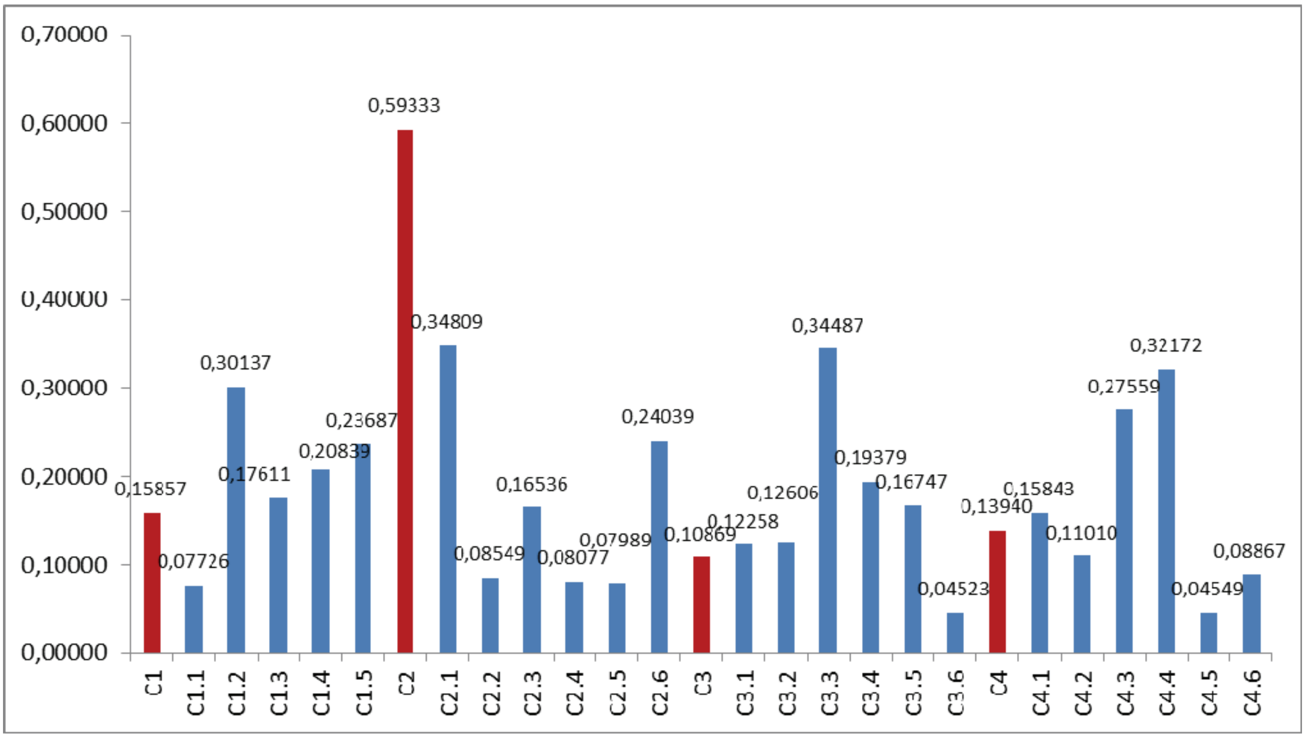

Figure 12: Weights for all criteria and subcriteria