USING AHM APPROACH TO POSITION CODP

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Abstract: The concept of Customer Order Decoupling Point/CODP is a popular approach to increasing the diversity of end items, while taking advantage of standardization/unification due to increased repetitiveness of operations devoted to components and/or subassemblies manufacturing. CODP marks the place (the operation, the phase of the process etc.) where customer intervention occurs, in order to define, according to his/her wishes, the final mode of the end item (product or service). An underlying issue here is to make an economically motivated decision about the exact CODP position (1) among different end items of the company's product mix, and (2) inside a particular product/service line. Inside the operations process, before CODP, forecasts are usually used (Make-To-Stock), and after it – Make-To-Order. Consequently, the opportunities to achieve economies of scale are different before and after CODP. Therefore, the opportunities for optimizing the total operating costs are different as well. In the present paper, an approach is suggested for applying the Analytical Hierarchy Process/AHP in solving such a problem. Some examples of criteria are also presented to give reasons for the "pros" and "cons" during the decision making process about CODP position.

1 INTRODUCTION

CODP stands for "Customer Order Decoupling Point". Often, for the same meaning, many authors use different terms and abbreviations, like "Customization Point/CP" (Ramachandran at. al, 2002) "Delay of Product Differentiation" (Gupta & Benjaafar, 2004), "Point of Postponement/ PP" (Feitzinger & Lee, 1997) etc.

CODP is a widely used tool in the process of applying Mass Customization and Co-Creation. It is a popular approach to increase the diversity of end items, while using the advantages of the standardization/modularization due to an increased repetitiveness of operations devoted to manufacturing of components and/or subassemblies. CODP defines the stage in the manufacturing value chain, where a particular product is linked to a specific customer order. In fact, it marks the place (the operation, the process phase etc.) where the customer's intervention occurs, in order to define the final mode and appearance of the end item (no mater a product or a service), according to his/her wishes and preferences.

In general, the idea of CODP is presented in the Figure 1 (Andreev, 2009). On the top of the figure, a simplified view is used to depict the sequence of operations and supplier-client relationships. It is represented by the subsequent steps of the whole supply chain – from the suppliers of raw materials downstream to the end client – the customer. According to the position of CODP, the customer is "allowed to penetrate" through the operational process, by the act of his/her order, using different options to choose at the CODP itself. Thus, the customer could define one or more particular subassemblies/components of the end item to be used in the final assembly, or the components of any particular subassembly, or a given combination of both, as well as to define certain component parts, and so on – upstream to the beginning of the process.

In fact, each of the end items built this way is a different customized product/service assembled according to the choice/preferences of the particular

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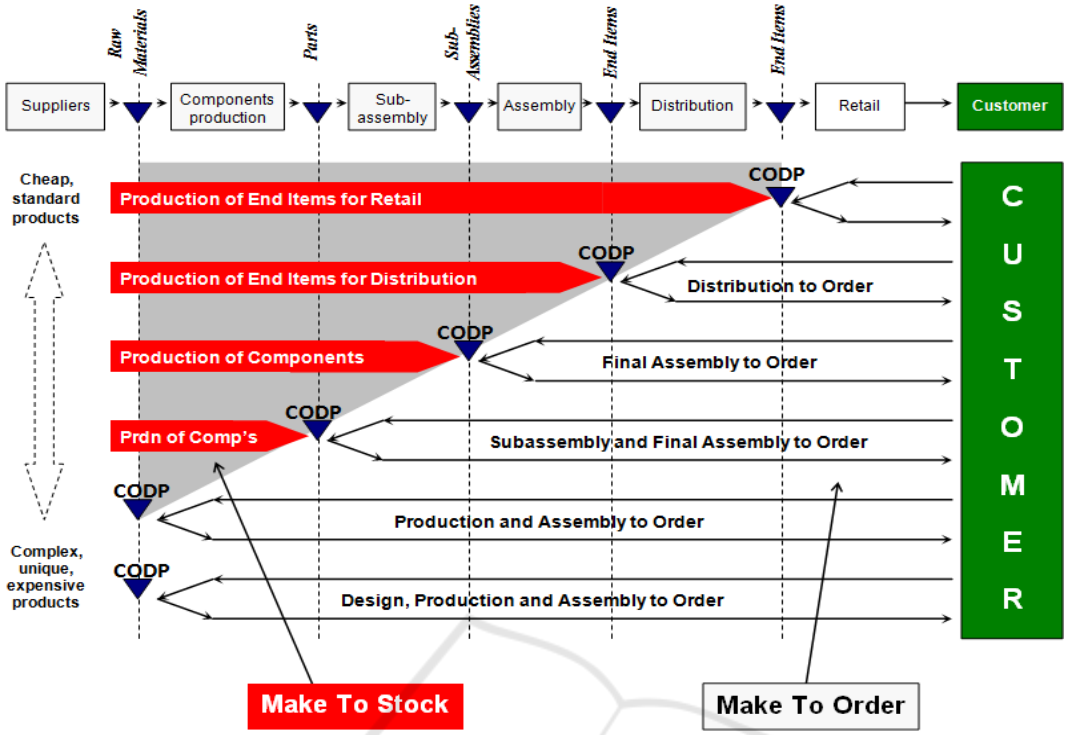

Figure 1: Variety of possibilities to position Customer Order Decoupling Point (Andreev, 2009).

customer. Moreover, the customer could be involved not only in choosing component options, but in performing some of the operations as well, likewise the case of home assembled furniture etc.

2 SPECIFICS OF CODP ISSUES

It can easily be seen from Figure 1 that moving CODP rightwards leads to a decrease in the end product diversity, and vice-versa. Also the opportunities for increasing product diversity by moving CODP leftwards are enhanced by, so to say, a kind of geometrical progression, due to the nature of the product breakdown structure, which "explodes" in quantity of generic items shifting down to the lower levels (Figure 2).

Acting this way, the company could combine the advantages of the Economies of Scope (a relatively rich diversity in the product mix, defined by the customer after CODP) with the ones of the Economies of Scale (aggregating and consolidating in batches as big as possible before CODP) with an aim to achieve a higher degree of customized variety of end products/services (Pine, 1992).

One can also see that both "boundary cases" are represented respectively: the upper one – 100% Sale-to-Forecast, and the one in the bottom – 100% Engineer-to-Order. In between, hybrids are possible to be performed that complement mutually each other, so that CODP sets their share (Figure 1):

– Distribution/Shipment to Order
– Packaging/Labeling to Order
– Assembly to Order
– Make to Order
– Purchase to Order

The problem of deciding on the right position of CODP for different product families, as well as for the products inside the product families arises periodically in the companies not only in connection with the continuously changing environment – both outside the company (new market conditions) and inside (new technologies, materials, operations etc.), but also because of the pursuit of continuously improving their competitiveness.

However, from an economic point of view, the companies aim to such a CODP position, which is not only going to help them take a competitive market advantage, but to provide also maximum benefits/profits.

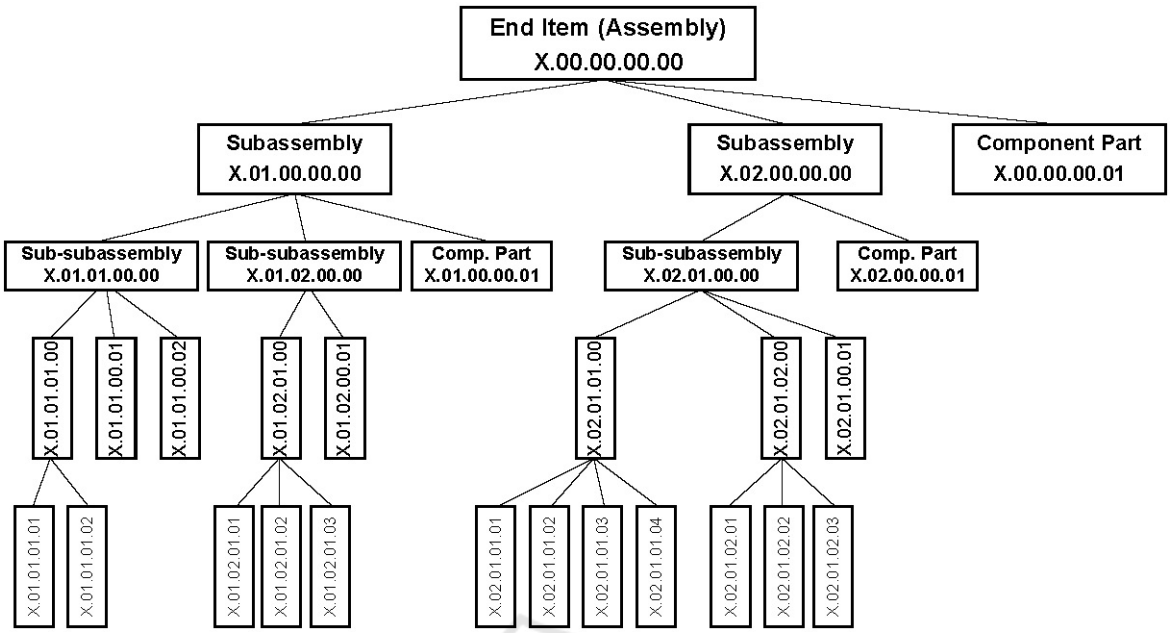

Figure 2: An example of a Product Breakdown Structure.

In determining the position of CODP, enterprises take into account the effect of a range of internal and external factors, which perform the role of selection criteria. These criteria build up a system and each of them can have its sub-criteria too. The simultaneous use of the whole range of criteria and their sub-criteria ensures a greater precision in the final estimates, but makes it quite difficult to determine them.

In their operations, enterprises are confronted with two major problems in determining CODP position: the first one is related to the correct establishment of the assessment criteria (influence factors) and their sub-criteria, and the second one – to the simultaneous taking into account of their effect.

Although several papers have discussed the conception of CODP, little work has been done on its influence factors and positioning (Olhager, 2001). Most often, it is noted that in the capacity of CODP it is possible to point out almost every component in the product breakdown structure (Figure 2), provided the enterprise is capable of suggesting alternative options for that component. Here, a modular design and structure of the end item is presumed so that it is possible to use any of the options in the further realization of the process at random (Velev & Tsvetanova, 2010). That also means that the capacity, which has to meet such a demand, should be extremely flexible and, as is most often the case, it will be to a great extent ineffectively utilized.

Our analysis of the publications points to the conclusion that it is necessary to suggest (1) a way of building up a complete system of criteria for decision making about CODP position and (2) a method/ set of tools, by means of which the decision will be based on a relatively large number of such criteria.

3 DECISION MAKING CRITERIA FOR CODP POSITIONING

In order to solve the first problem we suggest a system of criteria for assessment and selection. Their particular meanings, which take into account the impact of the internal and external factors, depend on the specifics of the activities of the enterprises and the conditions of the environment, in which they are carried out. The system includes a hierarchical decomposing of the criteria into sub-criteria, etc.:

3.1 Degree of Conformity with the Specifics of the Products/Services

3.1.1 Degree of Compliance with Customer Requirements

A higher degree of compliance with the characteristics of the products, provided with the customer requirements, presupposes a greater shift of CODP

leftwards. The less standard and the better the product suits the requirements of the customers, the more profitable it is for the company. With standard products the need to meet these requirements is decreased. The degree of necessary interaction with the customers is different and it depends on whether the enterprise provides a tangible product or a service. In case that services are provided the degree of interaction with the customers is generally greater, which causes a shift of CODP leftwards.

3.1.2 Strength of Technological Ties with Customers

The greater technological commitment to the customers requires a better co-ordination with them – for example, manufacturing of components to be assembled by the customer. On the opposite, when end products are manufactured, the technological ties are low and CODP shifts rightwards.

3.1.3 Mode of Contacts with Customers

When industrial products are being produced and delivered (i.e. machinery), the contacts with the buyers are much closer and direct. Most often, products are made to order by agreed specifications. No intermediaries are used in delivery, which facilitates the shift of CODP leftwards. However, that is not the usual case with consumer products.

3.1.4 Degree of Technical Complexity of the Product/Service

The technical complexity of the product/service requires greater involvement of the customer in developing, manufacturing and delivery of the product. It is necessary to have better interaction with the producer and that leads to a shift of CODP leftwards.

3.1.5 Degree of Diversity of the Product Variants

The greater degree of diversity of the product variants and the product quality characteristics require a greater degree of conformity and closer interaction with the customer requirements. Thus, opportunities for the realization of Co-Creation and Co-Development arise and CODP shifts leftwards.

3.2 Degree of Compliance with Market Conditions

3.2.1 Degree of Market Turbulence

The fast-changing customer requirements and the intensifying market fragmentation, which makes it necessary to satisfy the specific requirements of small groups of customers, have provoked immediate responses from the manufacturers. Modern business strategies have been employed, at the basis of which a shift of CODP towards the left is laid.

3.2.2 Degree, to which Competitors Make Use of the Practice to Involve Clients in the Process of Manufacturing and Delivering Products/Services

On the one hand, the practices of the competitors reflect the collective experience of the companies, which are active on the respective market, and the company must take them into consideration. On the other hand, the introduction of new business strategies by the competitors, related to the use of Co-Creation and Co-Development and a shift of CODP leftwards, forces the enterprise to react accordingly. Otherwise, it will lose its competitive edge.

3.2.3 Degree of Intensity of Market Competition

The strong competitive pressure forces enterprises to look for new ways of increasing their competitiveness. By shifting CODP leftwards, a greater degree of product customization is achieved, as well as a closer interaction with the customers and therefore – an improvement of competitive position. Usually, there is reduction in the manufacturing and marketing costs, and achievement of better business results.

3.2.4 Degree, to which Customers are Looking for Opportunities to participate in the process of manufacturing and delivering the product/service

3.2.5 Technological Opportunities for the Customers to participate in the process of manufacturing and delivering the product/service

3.3 Degree of Conformity with Enterprise Goals and Strategies

3.3.1 Expected Increase of Sales due to the CODP position in consideration

3.3.2 Expected Reduction of Costs due to the CODP position in consideration

3.3.3 **Expected Increase of Profit** due to the CODP position in consideration

3.3.4 **Expected Return on Additional Investment** needed to position CODP at the location under consideration

3.3.5 Degree of Conformity with the Company Strategies

The outcomes from a particular CODP position must fit into the company strategic choices and goals.

3.4 Degree of Conformity with the Production Capacity of Enterprise

3.4.1 **Technical / Technological Capabilities** of Enterprise, needed to provide the performance required

3.4.2 **Innovative Capabilities of the Enterprise** to meet customer requirements

3.4.3 Degree of Product Modularity

Greater modularity of the products presupposes greater variability of end items and higher degree of customization. It presupposes also easier realization of the Co-Creation and Co-Development practices.

3.4.4 Degree of Processes Flexibility

Flexibility of product development processes is yet another condition for greater variability and individualization. It presupposes a CODP shift leftwards.

3.4.5 Information and Communication Opportunities

ICT availability and status is vital in applying the practice of customer participation in manufacturing and delivering the products.

3.4.6 Degree of Integration with Intermediaries

The higher degree of integration of the enterprise with the intermediaries in the supply chain, such as suppliers or distributors, is a prerequisite for a shift of CODP rightwards.

3.4.7 Reputation of the Enterprise as a Loyal Partner

The positive reputation of the enterprise as a loyal partner, and one that maintains good quality is a prerequisite for increased customer commitment, leading to possibilities to shift CODP leftwards.

The above mentioned criteria can be changed and complemented depending on the particular conditions in which the particular enterprise operates.

4 METHODOLOGY FOR ASSESSING THE IMPACT OF DIFERENT CRITERIA

The second major problem related to determining the CODP position is connected with the simultaneous consideration of the whole system of criteria and sub-criteria, being used. In order to solve it, it is necessary to assess how strong the impact of each of the criteria and sub-criteria is, to evaluate their importance for obtaining desired final results, and to use an appropriate method for calculating the results according to various alternative positions of CODP. In addition, the method of assessment should avert or keep to a minimum the possibilities of errors and subjectivity in taking the final decision. The selection of CODP position should include a sequence of judgments and decisions, which have a hierarchical structure, as it is indicated in Figure 3.

In order to facilitate the procedure of choosing a position and to avoid or at least reduce subjectivity in taking the final decisions for the CODP location, it is recommended that the right assessment methods and software are used. An appropriate method for that purpose here is the Analytical Hierarchy Process/AHP (Saaty, 1980). AHP is a useful tool for choosing an option to be used out of a whole range of criteria, especially where there are sub-criteria to the criteria, sub-sub-criteria etc. Using that method, a choice is made based on the relative importance of the criteria and sub-criteria for achieving the aims set by the company strategy, and the capabilities of the operations to fulfil them.

The present paper aims at demonstrating, by using a simple example, the applicability of the AHP method in determining the position of CODP.

4.1 Determining the Relative Importance of the Selection Criteria

The criteria have different importance in maximizing the profits of the enterprise and for responding to the priorities of the customer. Thus, they carry different relative weights in making the decision about the choice of an option for CODP position.

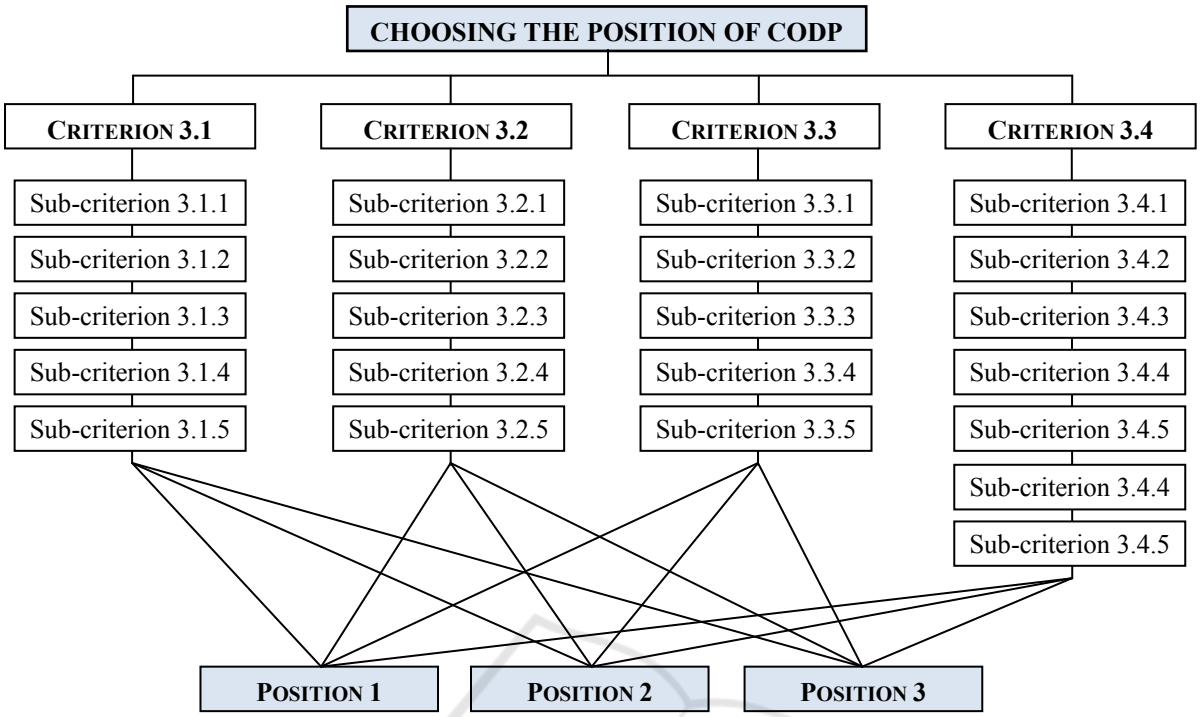

Figure 3: Decision hierarchy in choosing CODP position.

According to the AHP procedure, determining the relative weight of the selection criteria starts with their comparative assessment in pairs. This is done by a group of experts who use the assessment scale shown in Table 1 (Stevenson & Ozgur, 2007).

Table 1: Scale for determining the importance (priority)

Degree of Relative Importance	Score
Equal Importance	1
Between Equal and Moderate Great Importance	2
Moderate Great Importance	3
Between Moderate Great and Great Importance	4
Great Importance	5
Between Great and Very Great Importance	6
Very Great Importance	7
Between Very Great and Extremely Great Importance	8
Extremely Great Importance	9

The comparison stands for the relative importance of a certain criterion in relation to another one, in order to achieve that specific aim or in relation to another criterion at a higher level.

The levels of relative importance determined by the experts should be checked for inconsistency. If there is an inconsistency out of permitted boundaries, then the estimates should be reviewed. This is done by calculating the following ratio (Saaty, 1980)

$$CR = \frac{CI}{RI} \quad (1)$$

- CR – Consistency Ratio,
- CI – Consistency Index,
- RI – Random Index – defined according to the number (n) of objects compared in the following table (Panayotova, 2004):

n	2	3	4	5	6	7	8	9	10
RI	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

$$CI = \frac{\lambda - n}{n - 1} \quad (2)$$

- λ – Largest Eigen Value

The comparisons are considered to be consistent, when CI<0,10. (Handfield at al., 2002).

In order to demonstrate the applicability of AHP in CODP positioning we suggest the following example:

A choice must be made among three alternatives for CODP: **POSITION 1** (situated in the left part of Figure 1), **POSITION 3** (situated in the right part), and **POSITION 2** – situated in the middle.

As a result of the expert group discussions on criteria 3.1 to 3.4, the following matrix for comparing their importance pair wise is suggested:

Table 2: Comparing criteria pair wise with respect to the objective.

Criterion	3.1	3.2	3.3	3.4
3.1	1	1,000	0,333	2,000
3.2	1,000	1	0,500	2,000
3.3	3,000	2,000	1	4,000
3.4	0,500	0,500	0,250	1

After normalizing and calculating the first normalized principal Eigen vector, we come to the following distribution of priorities of the criteria:

Table 3: Calculating criteria priorities with respect to the objective.

Criterion	2.1	2.2	2.3	2.4	Priority
2.1	0,182	0,222	0,160	0,222	0,197
2.2	0,182	0,222	0,240	0,222	0,217
2.3	0,545	0,444	0,480	0,444	0,479
2.4	0,091	0,111	0,120	0,111	0,108

Calculations show that Consistency Ratio is within the limit: CR = 0.0076 < 0.1

What follows is to determine the relative importance among the pairs of sub-criteria for each criterion. A view on the present example is shown in Tables 4 to 7:

Table 4: Comparing sub-criteria 2.1.1 – 2.1.5 pair wise with respect to the criterion 2.1. Inconsistency: 0.071.

Sub-Criteria	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	Priority
2.1.1	1	3,000	4,000	3,000	4,000	0,433
2.1.2	0,333	1	2,000	2,000	3,000	0,208
2.1.3	0,250	0,500	1	2,000	3,000	0,156
2.1.4	0,333	0,500	0,500	1	4,000	0,140
2.1.5	0,250	0,333	0,333	0,250	1	0,063

Table 5: Comparing sub-criteria 2.2.1 – 2.2.5 pair wise with respect to the criterion 2.2. Inconsistency: 0.049.

Sub-Criteria	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	Priority
2.2.1	1	2,000	4,000	3,000	5,000	0,410
2.2.2	0,500	1	3,000	2,000	4,000	0,258
2.2.3	0,250	0,333	1	2,000	4,000	0,158
2.2.4	0,333	0,500	0,500	1	2,000	0,114
2.2.5	0,200	0,250	0,250	0,500	1	0,060

Table 6: Comparing sub-criteria 2.3.1 – 2.3.5 pair wise with respect to the criterion 2.3. Inconsistency: 0.042.

Sub-Criteria	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	Priority
2.3.1	1	2,000	2,000	2,000	3,000	0,331
2.3.2	0,500	1	2,000	2,000	4,000	0,263
2.3.3	0,500	0,500	1	2,000	3,000	0,190
2.3.4	0,500	0,500	0,500	1	3,000	0,146
2.3.5	0,333	0,250	0,333	0,333	1	0,070

Table 7: Comparing sub-criteria 2.4.1 – 2.4.7 pair wise with respect to the criterion 2.4. Inconsistency: 0.086.

Sub-Cr.	2.4.1	2.4.2	2.4.3	2.4.4	2.4.5	2.4.6	2.4.7	Priority
2.4.1	1	3,00	2,00	2,00	4,00	5,00	4,00	0,335
2.4.2	0,33	1	2,00	2,00	3,00	4,00	4,00	0,210
2.4.3	0,50	0,50	1	2,00	4,00	4,00	4,00	0,185
2.4.4	0,50	0,50	0,50	1	3,00	4,00	4,00	0,130
2.4.5	0,25	0,33	0,25	0,33	1	3,00	4,00	0,057
2.4.6	0,20	0,25	0,25	0,25	0,33	1	2,00	0,040
2.4.7	0,25	0,25	0,25	0,25	0,25	0,50	1	0,043

4.2 Determining the Relative Importance of the Alternatives for CODP Position

After defining specific weights for the particular sub-criteria, a pair wise assessment of the three alternatives for CODP position is made, according to each sub-criterion. An example for the sub-criterion 2.1.1 is shown on the Table 8:

Table 8: Comparing three alternatives for CODP position pair wise with respect to the sub-criterion 2.1.1.

Alt.	Position 1	Position 2	Position 3	Priority
Position 1	1	2,000	4,000	0,571
Position 2	0,500	1	2,000	0,286
Position 3	0,250	0,500	1	0,143

In that particular case, the above calculation is repeated 22 times with respect to each sub-criterion, followed by weighting these estimates to the corresponding weights of the main criteria. The summary results are presented in Figure 4.

According to the results, the first alternative for the position of CODP (the one on the left-hand side of Figure 1) is most preferable and best fits the criteria and considerations formulated in section 3!

5 CONCLUSIONS

In this paper, an approach to CODP positioning was presented, using the Analytical Hierarchy Process/ AHP. We summarized different approaches and existing methods to solving the problem. An in-depth analysis of some lacks in the literature in this direction enabled us to propose a different standpoint for the way of considering and solving the problem. The approach suggested here requires the decision to be made into two stages: (1) to build up a complete system of decision making criteria about CODP position and (2) to use the AHP in its capacity of a method/set of tools, by means of which the decision

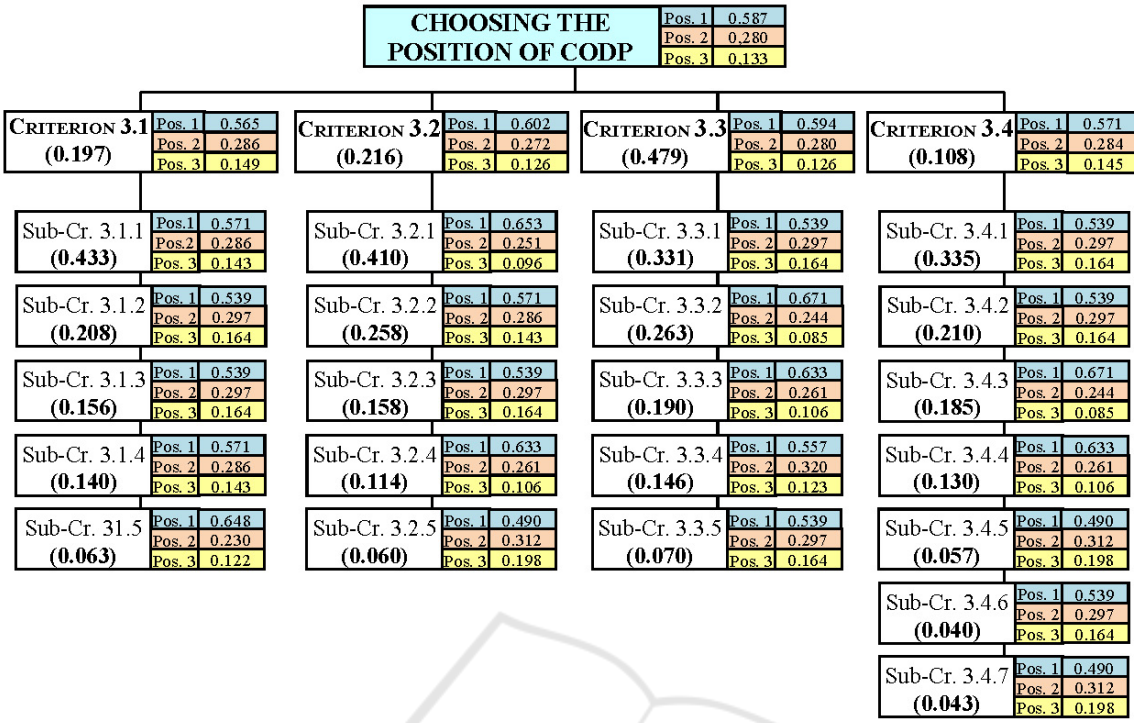

Figure 4: Comparing three positions with respect to the whole set of criteria and sub-criteria.

will be based on a large number of such criteria and sub-criteria.

In order to illustrate the approach, a hypothetical example was elaborated, based on the assumption of having three alternatives for the position of CODP.

First, a system of criteria and sub-criteria was build up, which reflects the particular circumstances and conditions influencing the hypothetical object under consideration, i.e. the specific branch of the company, the specific product/service, the specific competitive conditions at the market, financial considerations etc. Secondly, by using the AHP, these three alternative positions have been assessed with respect to the whole set of criteria and sub-criteria, and the one that fits best the criteria, was chosen.

Furthermore, it is necessary to make a vaster study in order to develop a method, which can consider the multi-positioning opportunities for CODP in the same product breakdown structure, as well as probabilistic behaviour of the units that manufacture/supply corresponding components.

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