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The Selecting of Complementary Products Using The AHP Method

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***Abstract*— The main purpose of recommender systems is to assist consumers find products and services they are interested in. When having already purchased one product, it is likely that the consumer may look for complementary ones to the product he already purchased. This paper proposes an Analytic Hierarchy Process (AHP) based model to help customers select the best complementary products. The selection is done according to certain criteria. Those criteria are in a first place evaluated and ranked in order to determine what are the factors that drive one customer to cross sell.**

***Keywords*— Recommendation system; Complementary recommendation; Analytic Hierarchy Process.**

I. INTRODUCTION

During the last two decades, Internet has proven to be a successful channel for marketing goods and services since it has removed barriers of distance and turned the whole world into one small village [1]. Indeed, moving toward electronic commerce has forced companies to adopt new strategies that could not exist with the physical commerce[2]. Besides, it has helped them to target new markets and provide customers with more options. As a matter of fact, companies can today gather easily and more accurately a large amount of information about customers [3]. Unfortunately, information overload raises many problems. Firstly, choosing a product to purchase, an article to read or even a video to watch has become such a complicated task for customers, as there are many alternatives to check and compare before they can select the best ones [4]. Secondly, understanding customers' expectations and assigning to them appropriate suggestions are such big concerns for companies as there is a huge amount of available information on consumers that needs to be properly exploited so as to better understand them and ensure high satisfaction for them [5], [6]. One solution to these problems is the use of recommender systems (RS). Recommending to customers what they really need or want is a key success of a recommendation system. Thus, RSs are becoming a core tool for enhancing cross selling practices as they help focusing marketing efforts not on all the customers but only on those who are more likely to act [7].

In order to enhance sales and satisfy consumers, e-commerce recommender systems provide three types of recommendations:

- Complementary Product Recommendations on the basis of cross-selling, up-selling and accessorizing approaches.
- Alternative Product Recommendations providing similar products to the one already bought.

The present paper describes a model for helping consumers on complementary products selection. The selection is done according to certain criteria. The proposed model uses the Analytic Hierarchy Process, which is a Multiple Criteria Decision Making method (MCDM) for the criteria evaluation and complementary products ranking.

This paper is organized as follows; the next section describes a literature review about recommender systems, cross-selling and complementary product recommendations. The section that follows is dedicated to discuss the implemented method (AHP) the model structure including the criteria evaluation process and the alternatives evaluation and selection.

II. LITERATURE REVIEW

A. *Recommender Systems*

RSs are decision support systems that help marketers tailor products, services and content to a customer depending on his personal interests and preferences [8]. They have been used in different domains: tourism [9], e-learning [10], e-commerce [11]. In electronic commerce, many large e-commerce sites are implementing recommender systems to make personalized suggestions [12] for customers about products to purchase [13], movies to watch [14], music to listen to [15], news to read [16] and restaurants to visit [17]. In general, they collect information about customers' online behaviour and feedback, and then provide suggestions based on their demographics, purchases history, features of items, preferences and tastes [17], [18].

B. *The Cross-Selling Concept*

Cross-selling means two concepts: providing existing customers with additional products and services to the ones

they already have [19] or with complementary products to the ones they have already purchased. Cross-selling has become a common marketing practice in many industries [20] since it helps create more value for both supplier and customers. Cross-selling help companies have stable business growth rates, which is achieved through a stronger customer ties, decreased customer churn rate and a sustainable competitive advantage. Studies have shown that adopting cross-selling strategies gives companies the opportunity to increase the revenue contribution from their existing customers [21]. In the other hand, it enhances customer retention since customer switching costs increases with increased cross buying [21]. In [22], the authors showed that cross selling help increase customers profitability and lifetime value, which in turn, leads to higher share of wallet and higher revenues [23].

Many RS enhance cross selling by analysing the history of the customers' activity in order to provide them with items they would be in need or they may want. Making decision about one complementary product/service to purchase can be influenced by many factors. Studying those factors and identifying the importance of one factor over another is basic in cross sell practices because it helps marketers identify what is the criterion or criteria that affect more the decision of buying a complementary product by one customer. In addition, they can recommend relevant complementary items according to the studied criteria, which in its turn led to increased customer profitability and satisfaction. In this research three criteria are being studied: product features, need and satisfaction.

C. Complementary Product Recommendation

RSs are becoming powerful tools for associating to consumers what they may need or may be interested in among a huge amount of product alternatives. In fact, consumers are relying more and more on recommendations provided by RSs because they allow them save time looking elsewhere and find what they really want. Complementary product recommendations consist of offering suggestions for products that will complement or complete the selection of the customers [24].

Complementary recommendations have been used by different systems. [25] proposes a recommendation system for chat discussion. The system recommends during the chat session complementary information based on the textual messages posted in the chat. The provided recommendations may be electronic documents and links to web pages, stored in a private digital library. In [26], the authors design a recommender system based on complementarity and similarity products. The system uses two algorithms, CSPAPT to offer recommendations based on customers' previous activity and CSPOPT to offer complementary and similarity products based on current buying to users. In [27], the authors present Sceptre, a model for predicting relationships of substitution and complementarity between linked products from their features including reviews and descriptions and are of two types substitutes and complements.

III. METHOD AND DATA

A. Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP), introduced by Saaty (1977 and 1994) is a MCDM approach that can be used to deal with complex decision-making problems. It helps the decision maker answers questions of the form « How important is criterion A relative to criterion B?» [28]; by developing an implicit trade-off in the course of structuring and analysing a series of reciprocal pairwise comparison matrices [29]. Over the years, AHP has become one of the most widely used multiple criteria decision-making tools for researchers and decision makers [30] because of its simplicity and ease of use. It has been widely used by decision makers in different fields such as resource allocation, Planning, Alternative selection, benchmarking, public policy decisions, healthcare, Optimization, conflict resolution and many more [31]–[33].

Supplier evaluation and selection is an important field where AHP has been extensively used [34]. In [35] a model based on the AHP is proposed and it determines the best supplier for purchasing computer and printers in General Directorate of Land Registry. The supplier selection is done according to 4 main criteria and 16 sub-criteria. [29] describes an AHP based model for the house selection process. The model allows buyers in the first place rank properties for possible purchases depending on their own preferences. Then they receive a set of houses weights with respect of each of the properties. In [30], the authors proposes an AHP based structure for identifying top strategies to implement by the State Securities Commission of Vietnam (SSC) so as to achieve a set of objectives. First pairwise comparison is applied to determine objectives and sub-objectives priority, and then strategies are evaluated according to the objectives. Marketing is also a field where AHP has been widely employed [36]. In general, it covers the following areas: generation and evaluation of marketing mix strategies [37], market modelling [38] and new product evaluation [39].

The methodology of the AHP can be summarized in the following steps:

The first step consists at developing a hierarchy by breaking the problem down into its components. The three major levels of the hierarchy are the goal, objectives, and alternatives [40].

The hierarchical structure is an efficient and intuitive way of dealing with complexity and identifying the relevant components of the problem. In that essence, AHP uses a hierarchy tree to hierarchically structure criteria and alternatives (Fig.1). The left end side of the hierarchy represents the goal to be achieved and the right end side represents the alternatives among which the best decision is to be made.

The second step is to determine the priorities of elements at each level. A set of comparison matrices of all elements in a level with respect to an element of the immediately higher

level is constructed. The pair wise comparisons are given in terms of how much element A is more important than element B. The preferences are quantified using a nine – point scale that is shown in Table1.

The third step aims to calculate the relative weights of the decision elements by calculating the weighted rating for each alternative by combining the alternative scores with the criterion. Next, a generation of a set of ratings for the decision alternatives is carried out by aggregation of relative weights is done.

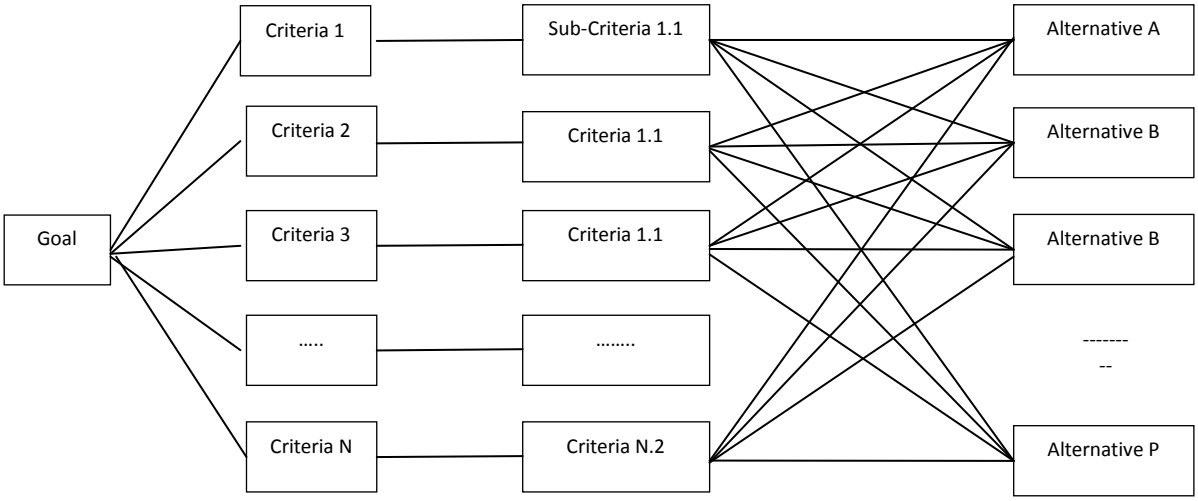

Fig 1: The hierarchical structure in AHP

TABLE 1: SAATY'S SCALE FOR PAIRWISE COMPARISON

Numerical value	Description
1	Equal importance
3	Slight importance of one over another
5	Moderate importance of one over another
7	Very strong importance
9	Extreme importance of one over another
2,4,6,8	Intermediate values between two adjacent values

B. Model Structure

When a consumer has already purchased a product or service, he/she may want to buy complementary ones because of different reasons. Some reasons are related to the first purchased product itself, whereas others depend on the recommended complementary products. This research studies the factors that can influence the consumer's decision to cross sell. Criteria taken into consideration are: Product features, Classification, Satisfaction, need and classification interest. The hierarchical structure of the problem is shown in Fig. 2.

The main criteria and sub-criteria are explained below:

- *Product features:* The customer's decision of buying a complementary product is deeply influenced by the features of the recommended complementary product, such as price, brand and classification.
  - *Price:* refers to the price of the recommended complementary product. It is considered an important influencer in customers' buying decisions.
  - *Brand:* the brand to which belongs the recommended complementary product. The first product and its complementarities can have similar or different brands.
- *Satisfaction:* satisfaction is an important factor since it influences the customer's next purchase decisions. In some cases, it is explicitly expressed by product rankings given by the consumer himself. Most recommender systems use a 1-5 rating scale to rate products. But in other cases, satisfaction is implicitly

derived through the customer' behaviour and his online activities.

- *Need:* need is a factor that drives the customer buying decision. A purchase cannot take place without the recognition of a need. It is crucial to predict a customer's needs in complementary products by analysing his/her past purchases and online behaviour.
- *Classification interest:* Customers may show more interest to some classification of products among the others. A consumer having interest in technological items is more likely to buy a cover for the iPad he already bought or a headset for his iPhone.

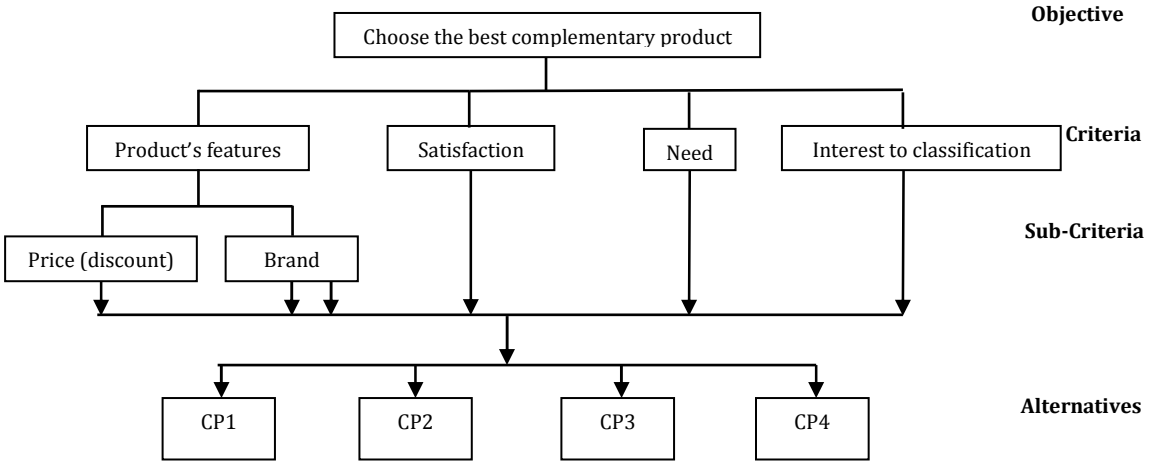

Fig 2. Hierarchical structure of buying a complementary product

C. *The Evaluation Process*

After having established the hierarchical structure of the problem, pairwise comparisons are carried out for all the factors in the hierarchy. One reason for filling out an entire matrix is to improve the validity of the judgments in the real world. Then, a calculation of the relative weights of the factors is made. Using pairwise comparisons, the relative importance of one criterion over another can be expressed. Table 2 and Table 3 show respectively the comparison between the main criteria and between criteria of Product features.

TABLE 2:
PAIRWISE COMPARISON TABLE OF THE PRODUCT FEATURES CRITERIA

Product features	Price	Brand
Price	1	3
Brand	1/3	1

In order to check the consistency of the judgments and make sure that the original preference ratings are consistent, the consistency ratio CR is to be calculated. CR is a comparison between Consistency Index (CI) and Random Consistency Index (RI) or in formula: $CR = CI / RI$

The Consistency Index (CI) is calculated by the formula: $CI = (\frac{\lambda max - n}{n-1})$ Where λmax n is the value corresponding to the proper maximum pairwise comparisons matrix and n is the number of elements compared. The Random Consistency Index was given by Saaty depending on the number of items being compared in the matrix. More CI, the greater the user's judgments are inconsistent and vice versa. If the value of CR is smaller or equal to 10%, the inconsistency is acceptable. If the CR is greater than 10%, subjective judgments are to be revised.

In the proposed model, the calculated CR for both the product features criterion and the main criteria is less than 10%, which means that the judgments in the model are consistent.

Next, priorities of the criteria are calculated using the pairwise comparisons in the judgment matrices. Table 4 describes the priority of each criterion with its rank among the other criteria.

In the first step of evaluation, alternatives' data are collected from an e-commerce website. Four complementary products (alternatives) are to be evaluated. The evaluation has been carried out by a comparison of the alternatives with respect to each decision criteria. Table 5 shows total weights of the evaluated alternatives.

The obtained results show that satisfaction is the most important criterion that drives one consumer to buy complementary products followed by the need, and then comes the product features. This means that if a purchased product satisfies the customer, then, driven by his need, and if showing interest to the product to buy classification, he will check the recommended complementary products by comparing their features. The evaluation of alternatives shows

that among the studied complementary products, CP3 is the best according to the product features, satisfaction, need and the classification interest criteria. The last preferred complementary product is CP1.

TABLE 3
PAIRWISE COMPARISON TABLE OF THE MAIN CRITERIA

Choose complementary products	Product features	Satisfaction	Need	Classification interest
Product features	1	1/5	1/3	5
Satisfaction	5	1	3	5
Need	3	1/3	1	3
Classification interest	1/5	1/5	1/3	1

TABLE 4
PRIORITIES OF THE MAIN CRITERIA

Choose complementary products	Priority	Rank
Satisfaction	0.55	1
Need	0.248	2
Classification interest	0.129	3
Product features	0.074	4

TABLE 5
TOTAL WEIGHT OF ALTERNATIVES

Alternatives	**Weights**
CP1	0.126
CP2	0.263
CP3	0.453
CP4	0.159

IV. CONCLUSION

The Analytic Hierarchy Process is a powerful tool when it comes to making consistent and formalized decisions that are based on multiple quantitative and qualitative criteria. The selection of one product/service to purchase depends on different factors that customers rely on in their buying decision. This paper showed a model that can be used by recommender systems in order to select the best complementary products to recommend to consumers. The selection process includes two steps. The first step consists of evaluating factors that drive customers to buy complementary products, while in the second step a set of complementary products are compared and ranked according to the criteria studied in the first step.

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