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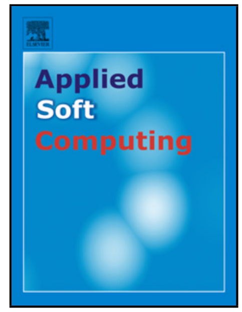

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FUZZY INFERENCE SUITABILITY TO DETERMINE THE UTILITARIAN QUALITY OF B2C WEBSITES

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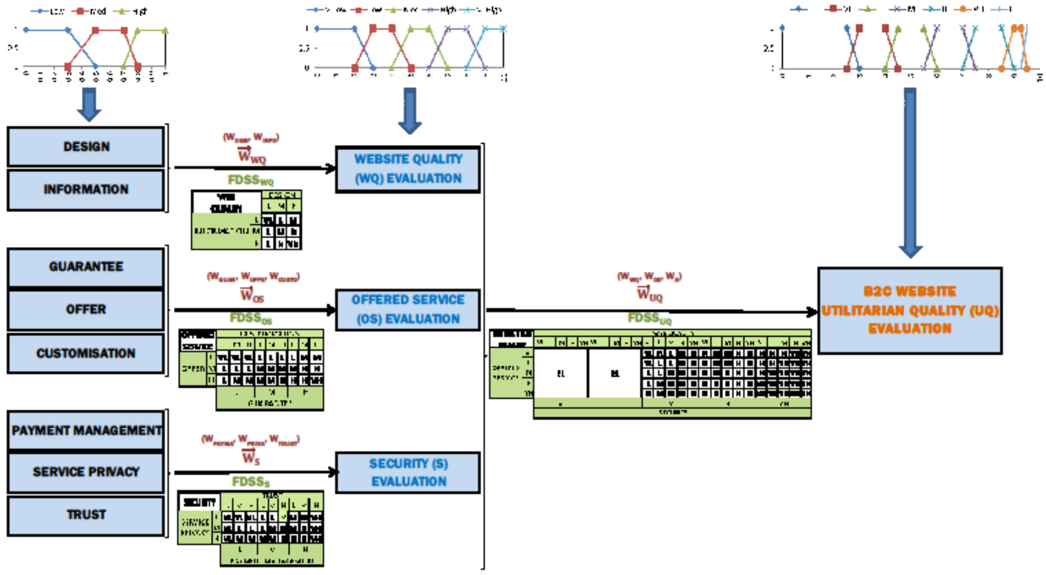
Graphical abstract



HIGHLIGHTS

- A model to evaluate the utilitarian quality in B2C websites is proposed.
- The model is focused on the textile and fashion sector in Spain and it is empirically validated.
- The B2C web evaluation by means of a fuzzy inference system shows two main advantages: a better management of non-linear behaviors and an easier way to collect and interpret the evaluation knowledge from experts or users through conditional linguistic rules –closer to the human reasoning mode-
- The model evaluation results can help companies identify their B2C websites strengths and weaknesses.

ABSTRACT

The present paper proposes a new and intuitive model to evaluate the utilitarian e-service quality on textile and fashion B2C websites in Spain. The relevant variables to include into this model have been validated through an in-depth literature review and a reliability study based on an empirical investigation. Among the several methodologies used to develop the model, the paper proves that fuzzy inference systems (FIS) have numerous advantages. The following are particularly relevant: the ease to manage non-linear behaviours and the intuitive way of incorporating knowledge to evaluate B2C websites. This knowledge can stem both: from the expert know-how or from the evaluation of consumer satisfaction on these websites. The knowledge is made explicit

through if-then rules which work with linguistic-type concepts -agreed upon by experts, closer to the human reasoning mode. Finally, the usefulness of the proposed model and the defined FIS suitability to evaluate the model are shown.

1. Introduction

The frequency and depth of the use of the Internet are increasing worldwide. It is used for many daily activities, from email communication or browsing for information, to entertainment and shopping. This growth has supposed business opportunities, opening up a vast new territory, which business are eager to explore, and resulting in more consumers and companies choosing the Internet as means of purchase and sale.

Among the different types of E-commerce, Business to Customer (B2C) technology covers those websites and transactions through which organisations sell goods and services to customers directly over the Internet. Efficiency and cost effectiveness of this technology have already transformed the web into a global environment for business. Nevertheless, consumers find many difficulties in the online purchasing processes that have to do with searching and browsing websites, evaluating and comparing products or with the payment process among others. All these inconveniences affect the satisfaction of customers with the B2C websites [01]. The study of consumer's satisfaction plays a fundamental role in the survival and success of the company, given its impact on the repurchase behaviour and in the word-of-mouth recommendations (WOM). Moreover, higher consumer satisfaction degrees usually imply better commercial and financial results for the company [02]. Also, the dominance of internet as a shopping and distribution channel demands an understanding of e-service quality for online retailers to attract and retain online shoppers in this virtual environment [03].

According to the National Commission for Market and Competence annual report (2015), the areas of activity with the highest percentage of e-commerce turnover in Spain are: Travel agents and tour-operators (13.2%), Flights (10.3%), Textile-and-fashion (TF) (7.8%) and Direct marketing (6%) [04]. Nevertheless, despite the growth of TF sector in recent years, we have not found extensive studies describing the online shopper profile in the TF Spanish market nor have we found valuation of their satisfaction regarding relevant e-service quality (eSQ) factors on B2C websites.

The evaluation of e-service quality in TF-B2C companies can be considered as a multiple-criteria decision making (MCDM) problem with many quantitative and qualitative attributes. Up to now, several models have been developed for evaluating consumer satisfaction regarding B2C websites [05]. Most evaluation models are mainly focused on two approaches: the technological one and the consumer–centred one. The technological approach focuses on infrastructure quality: telecommunications, information technology, internet infrastructure and services provided (customer self-service, customer relation management and business intelligence support). The consumer-centred approach focuses on usability, consumer behaviour and service oriented features [06]. The former evaluates mainly utilitarian quality attributes meanwhile the second one evaluates attributes related to hedonic quality.

However, some of these models have been criticized for their lack of standardisation, failure to develop well-defined outcome measures, and lax methodological rigor [06].

Furthermore, there may also be problems when implementing the models due to a) the lack of consensus in defining and assessing their key variables (dealing with models that vary from the simpler ones with little exactness, to the most complex models with difficult implementation) b) the difficulty of processing the uncertainty associated with scoring certain variables involved in the evaluation and c) the difficulty of conceptualizing the knowledge inherent to the B2C website evaluation. Hence, it is important to develop new instruments and scales directly oriented to B2C e-commerce interfaces and applications.

Some of these problems could be reduced by using artificial intelligence techniques that have already proved their worth in industrial development by providing support to management processes, helping in decision making, design of processes and practical applications. In particular, fuzzy inference systems (FIS) have been successfully applied in many fields -medicine, environment, marketing, aeronautic, banking, among others- and have shown excellent performance [7, 8, 9]. This success lies in their ability to manage uncertainty through an appropriate treatment of natural language, used by human beings in their reasoning and decision-making processes, when dealing with vague and imprecise data.

Thus, this paper proposes further investigation on online shopping in Spanish TF sector from several perspectives. Firstly, by identifying their most relevant eSQ factors and their constituent attributes. Secondly, by proposing and validating an eSQ evaluation model for TF-B2C platforms. Thirdly, by analysing and comparing two different B2C websites evaluation methods: a traditional weighted point method (with assessments based on crisp numerical scales) vs. a fuzzy inference system (based on linguistic assessments agreed by experts).

The paper is structured as follows. Along section 2, literature reviewing and expert panel help to identify the attributes, factors and dimensions of the proposed e-SQ evaluation model. Afterwards, the model is validated through an empirical investigation. In Section 3, two different B2C websites evaluation techniques are explained: one of those based on weights, and the other based on fuzzy logic. In Section 4, some numerical examples of both techniques -working over different textile-and-fashion B2C websites in Spain- are provided, discussing their advantages and disadvantages. Finally, the conclusions are stated in Section 5.

2. Literature review and conceptual model

The aim of eSQ models is to identify and know the evaluation that users make of different eSQ dimensions that contribute to the website's success. Parasuraman, et al. (2005) [10] define e-service quality as the "extent to which a website facilitates efficient and effective shopping, purchasing, and delivery".

2.1. e-Service Quality dimensions and proposal of an eSQ evaluation model.

Several eSQ models try to identify the factors and latent dimensions that significantly contribute to their valuation. This valuation is generally supported by questionnaires (with Likert-type scales) filled in by potential customers. Some of the most commonly used eSQ models are: SiteQual [11]; e-SERVQUAL [12]; WebQual [13]; PirQual [14]; eTailQ [15]; E-S-Qual and E-RecS-Qual [10]; eTransQual [16]; NetQual [17]; PeSQ [18]; SERVCON [19], Co-Creation [20] and Service-Dominant Logic [21].

Eight main factors related to the utilitarian eSQ dimensions were identified in most of the reviewed models: Design, Information, Guarantee, Offer, Customization, Payment Management, Privacy and Trust. A brief description of these factors are summarised in Table 1, pointing out their relevance in B2C websites evaluation.

An expert panel assisted to define our eSQ evaluation model. The panel was arranged upon interviews to different experts in online marketing. The main goals of the expert panel were a) to determine the correct allocation and precise wording of the attributes (observable variables) that should integrate each factor of the model; b) to group the factors into the latent dimensions that explain the B2C websites utilitarian quality about the TF sector in Spain, and c) to reach an agreement on both the range partition of the model variables and the definition of rule bases in the proposed FIS.

Twelve people took part in the expert panel; six had an academic profile (marketing professors in Spanish Universities) and the other six had a professional profile (persons in charge of websites related to TF sector corporations). They were asked about a proposal of attributes (for each one of the defined factors) collected from a previous review study on this topic, where papers after 2000 were analysed in different top databases and Management Journals –Web of Science, Scopus, EBSCO, Journal of Retailing, Information & Management, Journal of Service Research, European Journal of Information Systems, among others.

After defining, removing, reallocating and precise wording of the remain attributes in the model, the measurement scale shown in Annex A was proposed. Besides, it was concluded that: (a) design and information factors could be grouped into the latent dimension called "Web Quality"; (b) guarantee, offer and customization factors into the "Offered Service" dimension and (c) payment management, privacy and trust factors into the "Security" dimension. With this information, the eSQ evaluation model for TF sector in Spain illustrated in Fig. 1 was proposed.

The initial consensus reached among panel members allowed to establish: a) the proper partition ranges of the factors and their underlying qualification labels –averaging the cut off points proposed by the experts (Table 2)- and b) the importance of the weights for the model factors -by the analytical hierarchy process AHP [31] (Table 3)-.

2.2. Model Validation

With the information obtained from the expert panel, a questionnaire was made (based on Annex A) so that a sample of 405 regular users of TF-B2C websites showed their opinion about different dimensions of our eSQ model. The surveys were delivered through social networks (Facebook, Tuenti, LinkedIn and Twitter), e-mail and personal interviews. To select the sample of respondents different databases on customers' fashion and snowball sampling approach were used. Table 4 shows the survey's technical report. Respondents were regular customers of the six main analysed retailers: Zara, Vente Privee, Privalia, Buy Vip, Asos and eBay.

From this survey, in order to validate the structure of the proposed model, the psychometric properties (one-dimensionality, reliability and validity) of the measurement scales used to explain each factor of e-service quality were analysed.

To check the one-dimensionality (existence of a unique concept underlying the set of attributes that explain each factor), alpha-Crombach coefficients were calculated upon exploratory factorial analysis of main components with Varimax rotation, using IBM SPSS Statistics 19 software. Table 5 illustrates the result of analysis once removed the attributes DESI1, DESI2, DESI7, INFO2, CUSTO1, CUSTO3, PAYMA3 and TRUST3 for failure to comply with this criterion –marked in italics in Annex A-. As can be seen, in all cases, factorial loads, explained accumulated variance percentages and α Cronbach coefficients were greater than 0.5, 50% and 0.6, respectively -threshold values recommended in exploratory studies [32]-.

Moreover, since “Web Quality”, “Offer Service” and “Security” latent sub-dimensions present multidimensional nature, a second order factorial analysis was carried out to confirm their composition and decide the individual or collective treatment of their constituent factors. The indexes of goodness of fit obtained by applying the confirmatory factorial analysis (using EQS 6.2 software) allowed to confirm the existence of second-order factors that explain each analysed latent sub-dimension. Therefore (a) design and information factors can be grouped into the latent sub-dimension called “Web Quality”; (b) guarantee, offer and customization into “Offer Service”; and (c) payment management, privacy and trust into “Security” sub-dimension.

To evaluate the reliability, the structural model proposed in Fig. 1 is analysed by using EQS 6.2. After obtaining standardised lambda parameters of each attribute, composite reliability indexes of the factors were calculated –degree of inner consistency of the attributes to represent the common latent factor- and their average variance extracted (AVE). The results obtained by this method are shown in Table 6. In all cases, composite reliability indexes and AVE values are greater than 0.6 and (0.5-0.7) respectively -minimum values recommended by several authors [32, 33]-.

To determine the validity of the measurement scales used to explain each eSQ factor in B2C web platforms, three types of validation have been performed: content, convergent and discriminant validity. Content validity is accepted since the measurement scales have been designed taking into account both the attributes contained in measurement scales validated in previous studies and the improvements proposed by the expert panel. Since all standardised lambda parameters have resulted significant (values greater than 0.5) convergent validity is also proved. Finally, appropriate confidence intervals of the correlation between factors were calculated (in no case do they include value “1”), so discriminant validity of the factors can be confirmed [33].

The following conclusions may be drawn from this analysis: a) The eSQ evaluation model proposed in Fig. 1 is reliable and valid, once the attributes DESI1, DESI2, DESI7, INFO2, CUSTO1, CUSTO3, PAYMA3 and TRUST3 have been removed; b) Utilitarian Quality can be explained by three latent sub-dimensions (and their corresponding factors): Web Quality (design and information), Offer Service (guarantee, offer, and customisation) and Security (payment management, privacy and trust).

3. Techniques to evaluate the model

To evaluate the dependent variables within the evaluation model, it has been decided to use two alternative methods. In the first place, a weighted point method (WPM), given its ease of use and implementation. Secondly, a fuzzy inference system (FIS), which mitigates some inconveniences found in the first method and allows checking the knowledge consistency inserted in the rule base to evaluate B2C websites.

3.1 The weighted point method (WPM)

In this method, the scores of the dependent variables of the validated model are calculated by weighting the scores of the variables that influence its value. In our case, those importance weightings were agreed from the expert panel on B2C websites evaluation (see Table 5), although they also might stem from the survey made to these websites' regular customers.

Next, the formulation defined to evaluate each subsystem in the model is shown (where Wi designs the weight associated to variable "i", and all the independent variables in brackets are ranged between 0 and 1 –these weights and ranges were standardised by expert consensus in this evaluation method-).

$$[\text{Web\_Quality}] = \{W_{DESI}\cdot[\text{Design}] + W_{INFO}\cdot[\text{Information}]\}\cdot 10 \quad (1)$$

$$[\text{Offered\_Service}] = \{W_{GUAR}\cdot[\text{Guarantee}] + W_{OFFE}\cdot[\text{Offer}] + W_{CUSTO}\cdot[\text{Customisation}]\}\cdot 10 \quad (2)$$

$$[\text{Security}] = \{W_{PAYMA}\cdot[\text{Payment Management}] + W_{PRIVA}\cdot[\text{Service Privacy}] + W_{TRUST}\cdot[\text{Trust}]\}\cdot 10 \quad (3)$$

$$[\text{Utilitarian Quality}] = \{W_{WQ}\cdot[\text{Web Quality}] + W_{OS}\cdot[\text{Offered Service}] + W_{S}\cdot[\text{Security}]\}\cdot 1 \quad (4)$$

One referred to "Security" should be considered a critical and discriminant factor within the evaluation process [22], because if customers perceive a flaw in the website's security or in the method of payment, they will be less willing to purchase no matter how good scores the website has regarding Web Quality and/or Service Offered. This fact, in the WPM, would require to generate a previous check to the common application of the arithmetic method that let it disqualify the websites that do not fulfil the minimum requirements in that variable Security, or at least to penalise them.

Another additional inconvenience is the need of normalizing the values of the variable "guarantee" to make them fall within the ranges of the evaluation system. This problem might also hinder the use of the WPM.
Besides, the WPM does not allow aggregating the decision knowledge to score the dependent variables in a guided and intuitive way, making the evaluation process less transparent. Such inconvenience could be avoided by using inference systems based on expert rules.

On the other hand, the nature of B2C e-commerce customers' decisions is complex and little structured since the estimate of some qualitative and quantitative factors involved in the evaluation is subject to high levels of uncertainty and subjectivity -for instance, the perception of security and the loyalty of a customer, as Meziane and Nefti [34] remark-.

These entire inconveniences highlight the rigidity set by the WPM to evaluate B2C websites in spite of its ease of calculation. As a result, it is proposed to analyse the appropriateness of setting up an evaluation method that allows to mitigate the aforementioned inconveniences, and that is able to emulate human reasoning processes in decision making from ill-defined or vague data [23] –as has already been proved in other ambits [35, 36, 37]-. This would be feasible by expanding the previous method to a fuzzy inference system, which allows inferring the B2C e-commerce evaluation of different companies according to experts on B2C websites evaluation or through evaluations provided by customers. Once the evaluation has been made, it will be possible to establish a ranking with the best positioned companies within a business sector.

3.2. Evaluation through fuzzy inference systems (FIS)

FIS are based on Fuzzy Sets Theory [38]. They allow to aggregate components of uncertainty to the model which makes them more efficient in representing reality [39]. In these systems, the variables, of linguistic type, allow to process qualitative as well as quantitative information since they take labels related to common language as values. This is in contrast with traditional numerical variables that take as values exclusively numbers [40]. In the specific case of B2C websites evaluation, the inherent subjectivity associated to some determining variables of the model may be high. That is why, to treat linguistically these variables, allows a better management of the evaluation criteria provided by users or by the experts about this kind of websites. In addition, it will be proved that the design of a fuzzy system in this ambit leads to a better interpretation of the knowledge embedded in the evaluation model and a bigger soundness of its evaluation behaviour compared with other simpler evaluation systems – i.e. the ones based upon weights-.

First of all, it will be necessary to define the FIS knowledge base from the experts know-how. On the one hand, experts will agree on the range and form of the fuzzy labels in which the dominions of the model variables must be partitioned. Later, they will agree on the set of linguistic rules to build up with these fuzzy variables, capable to explain all possible evaluations within each model subsystem.

3.2.1 Variables domain partitioning and knowledge elicitation for rule bases

To define partitions and rule bases, 6 out of 12 participants in the expert panel accepted to take part in this study. Firstly, in order to homogenize the problem, it was agreed to establish the same number of labels for all input and output variables of the model subsystems. To reach an agreement among experts, odd scales of 3, 5, 7 and 9 labels were proposed in line with other research [41]. After rounding arithmetic means of the values assigned by the experts it was decided to use 3 and 5 labels for all input and output variables of the initial subsystems respectively. Similarly, in the final subsystem, it was agreed to use 5 and 7 labels for their input and output variables.

The semantic representation of the labels was associated with trapezoidal fuzzy numbers (TFNs), since many authors consider them robust enough to represent the vagueness of linguistic assessments given by the sources of information [42]. Likewise, it was decided to use strong fuzzy partitions [43] as they are the best ones in terms of comprehensibility by satisfying important semantics constraints as distinguishability, normalization, coverage or overlapping [44].

To define the partitions, a 2-tuple fuzzy linguistic representation model based on a symbolic translation was used. This model allows to represent and manage linguistic information by means of a pair of values (si, αi) where “si” is a linguistic term (from an original set “S” of linguistic terms) and “αi” is a numerical value assessed in [-0.5, 0.5) representing the symbolic translation. A detailed explanation of this model can be found in Herrera and Martinez [45].

Firstly, a set of preference linguistic terms was defined (see Table 7) so that experts could assess different core-width structures of the labels in each variable of the proposed model.

By way of example, Fig. 2 illustrates four eligible structures related to the core-width of the partition label set (based on the initial proposed ranges from Table 2 for the input variables in the "Web Quality" subsystem). Later on, experts gave their ratings on linguistic preferences regarding these four possible structures, as is shown in Table 8.

As aggregation measure for the joint valuation of each structure, the "Extended Arithmetic Mean (EAM)" -based on the order of the labels within its scale- was used [44]. For example: EAM (Struc_1) = (0*1+1*2+2*3)/6=1.33. From these values, 2-tuples associated to each structure were configured by a symbolic translation process, based on the interval [-0.5, 0.5). Therefore, each 2-tuple identifies the original preference label nearest to the calculated EMA and its closeness (to left or right) –See Fig. 3-. Once the 2-tuples of all the alternative structures have been identified, the one that represents the highest preference -according to their lexicographic order- is chosen (in this case, "Struc_1").
Finally, from the width-core structure agreed by this method, the semantic of each label is developed by means of TFNs, taking into account the established criterion of achieving a strong partition in each variable. Fig. 4. illustrates the final partition of the “Web Quality" subsystem input variables as an example.
Following the same procedure, the rest of the partitions in the proposed model were obtained, as can be observed in Fig. 5.In order to define rule bases, a knowledge elicitation method based on the extension principle was used [46]. In a first phase, experts were asked to choose their preferred output labels for each combination of input ones in the fuzzy inference subsystems of the proposed model, according to the partitions predefined. The first columns of Table 9 show the ratings obtained for the "Web Quality" subsystem. From these valuations, collective preference vectors (CPV) -associated with each label combination of two input variables (DESIGN and INFORM)- were obtained by using the arithmetic mean aggregation method (according to the extension principle). For example, the first value in this table is calculated as: (0+2+0+2+0+0)/6 =0,67. These collective fuzzy values do not match any original linguistic terms exactly, therefore, a linguistic approximation process based on the Euclidean distance was used to obtain the results in the initial set of terms {VL, L, M, H, VH}:

$$D([a_i,b_i,c_i,d_i]-[a^j,b^j,c^j,d^j])=\sqrt{P_a(a_i-a^j)^2+P_b(b_i-b^j)^2+P_c(c_i-c^j)^2+P_d(d_i-d^j)^2}$$

being $[a_i,b_i,c_i,d_i]$ the i[th] preference vector, $[a^j,b^j,c^j,d^j]$ the j[th] label of the original partition and Pa, Pb, Pc and Pd the importance weights assigned to TFN apexes.

Considering the obtained CPVs, the partition terms of the output variable {VL, L, M, H, VH} and taking: Pa = Pd = 0.15 and Pb = Pc = 0.35, the Euclidean distances were calculated as shown in the last columns of Table 9 Finally, the minimum distance in each row allowed to identify the final assigned label in each of the 9 combinations of "Web Quality" subsystem.

In order to assign the labels for the output variables of the other subsystems, the same procedure was used, obtaining the rule bases illustrated in Fig. 6. At the top, bottom and on the left end of these tables, input variables of each subsystem (and their assignable labels) are illustrated. The central body of the tables shows the agreed labels assigned to the output variable in each label-combination of the input variables

For instance, the shaded cell in the third table of Fig. 6 -related to the “Security” evaluation- expresses the rule: if the score of “payment management” is medium and “service privacy” is low and “trust” is high, then, the “Security” evaluation is medium.
The fuzzy method’s configuration itself allows taking into account certain nuances that were regarded as inconveniences in the WPM. For instance, it could be proposed that if a user scores the web security as low or very low, the final evaluation assigned is extremely low avoiding a good evaluation of the website (no matter the values of the rest of the input variables – check the first and second blocks of rules of the last rule base-).

3.2.2. Mamdani FIS. Inference Maps for the model subsystems.

Mamdani type fuzzy inference systems, supported by all the aforementioned, allow to make inferences through a process that consists of five stages [47]: fuzzyfication, application of logical operators in every rule’s antecedent, implication to every rule’s consequent, aggregation of all rules’ consequents and defuzzyfication of the final aggregate. A Mamdani fuzzy inference system seeks to infer a crisp numerical value for each of its output variables as a function of the crisp values given to its corresponding input variables. Firstly, these values are fuzzified, that is, they are converted to truth values - between 0 and 1- according to the labels intercepted in its corresponding partitions in all the rules. Then, applying the convenient operators to these intercepted values in the antecedent of each rule -according to the logical connectives that link its variables-, a global truth value for each rule is obtained (the "min" operator is usually considered for the “and” connector). In the implication phase, the global truth value of a rule (activation level) is transmitted to its consequent -generally truncating the label of its output variable to that activation level-. In the aggregation phase, the truncated output labels of all active rules are grouped (usually overlapping them and choosing the path of maximum truth values). Finally, the aggregated fuzzy set is defuzzyfied to obtain the final crisp value of the output variable (usually by calculating the abscissa of its centre of gravity). Although the methodology may appear to be operationally complex, there are multiple software programs to carry out this evaluation process in a simple way by simply defining the labels associated with the system variables and the rule base that incorporates the decision knowledge. The software Matlab fuzzy logic toolbox ® ver. 2.0. [48] was used to develop our fuzzy inference system and a detailed explanation of this process in that tool can be accessed from Mathworks Web [49].

Once all the fuzzy subsystems have been designed, the final evaluation of the model can be inferred from them as a function of the crisp values given to their input variables. What is more, it is easy and intuitive to analyse the congruence of the obtained evaluations by using the inference maps supplied by each model’s subsystem. In these maps, the scores of the input variables are represented by the height of the surface in each point.

For example, Fig. 7 shows the evolution of the "Security" evaluation as a function of the "privacy" and "trust" values, for different levels of the factor "payment management". It is seen how this factor [payment management] is determining in the online purchase decision process, since customers perceiving low payment management on the website, will only be able to get acceptable assessments regarding "Security" if the two other variables scores are very high. However, medium and high values in [payment management] (central and right graphs) result in an increase in the value of the output variable which can reach 7,5 or 9 points respectively. In this case, values of the variable [trust] over 6 points, result in much higher evaluations than those obtained in the case of medium payment rates regardless the value of [privacy] (this explains the fact that customers that perceive a secure and reliable service, reward the final evaluation regardless the privacy since customers do not believe it to be affected). That is why companies should provide all type of reasons, and specify the different available ways of accomplishing payments (online and offline) depending on customers' needs.

The final Utilitarian Quality of a B2C website can be analysed as a function of two input variables (resulting from previous subsystems) while keeping constant a third variable's value not shown in the graphic.

An option to analyse this model, would be to represent the final evaluation vs. the [Offered Service] and [Security], given different levels of the [Web Quality] (Fig. 8). If the web quality is low –left graph-, it is seen that [Security] values under 5 result in no output (regardless the "Service" and the "Web Quality" evaluation) as defined in the rule base. As [Security] values grow higher, the final evaluation grows as well, reaching maximum values around 8,5. It is also seen that [Web Quality] higher values –right graphic- result in higher values in the final evaluation for a wider area, regardless the Offered Service level.

Another option to perform the analysis could be to represent the final evaluation vs. [Web Quality] and [Offered Service] (Fig. 9), given different "Security" levels of the website.

It is seen that low values (under 5) in the variable [Security] result in the B2C website being significantly penalised (because customers' security perception is not good, and therefore they will not purchase online), as defined in the rule base. In the case of medium-high values in [Security] (central and right graphics respectively), customers are more likely to purchase, widening the area with higher scores and reaching evaluation plateaus of 8 and 9 points respectively.

4. Numerical examples. Results and discussion.

To compare the aforementioned behaviour, the six preferred websites from the survey have been evaluated by both methods. The results are shown in Table 10 (according to the weights on Table 5). The last column of this table shows the variation rates (%) - calculated as $\left(\frac{Eval_{FIS}-Eval_{WPM}}{Eval_{FIS}}\cdot 100\right)$- between both methods regarding the utilitarian quality evaluation in all the analysed websites (for example, a rate variation of 12% was found on Privalia´s website).

In view of the results, moderate variation rates are found when comparing WPM and FIS in all analysed actual websites (from 5,93% on eBay to 15,58% on Asos). As can be seen, FIS gives a more optimistic assessment on highly valued websites (as is the case of all the analysed websites). However, on poorly valued websites (or with a very low value in a critical variable –e.g. “payment management”-) a good evaluation method should highly penalise the ratings given to the portal, which should result in a very high variation rate compared with WPM.

There are not substantial differences between both methods on the six webs analysed (due to the high average values obtained from the survey in all the variables of the evaluation model). However, given the linear character of WPM, important valuation differences might appear if a minimum threshold of acceptance is required in a critical variable of the model (e.g. it may be appropriate to penalise a B2C website with low security –since customers will not perceive enough safety and will probably quite the purchase-). It is the case of “web Z” on Table 10 -fictitiously introduced to reflect this fact- with high values in the variables related to “web quality” and “offered service” dimensions and a very low value (0,3) in the critical variable “payment security”. When FIS is used, such a low value in that critical variable provides a heavy penalisation in the utilitarian quality evaluation (1,35) -since the defined rule base allowed to incorporate non-linear behaviours in the evaluation method-. However, the lineal character of the WPM does not penalise so drastically the utilitarian quality of this website (6,0). This disparity caused an extremely high variation rate between both methods (77,5%), showing a better fit to the reality of the FIS method, especially when a non-linear behaviour is expected.

It must be added to this problem, the necessity of previous normalisation of some variables in the WPM, so that all variables in a subsystem are expressed within the same range of scoring. In our example, this problem (seen in the variable [Guarantee]) is solved by using the FIS since it allows to incorporate the evaluation knowledge through linguistic labels in which every variable dominion is partitioned, regardless its unity of measurement. Thus, the recodification of this kind of variables –e.g. by means of a subjective interpolation function- is avoided.

Furthermore, the FIS method has pointed out the ease to build in a guided and intuitive way the evaluation knowledge required to evaluate websites through conditional fuzzy rules, either from the expert knowledge or from the opinions stated by the users of the websites. In addition, it provides diagnostic tools, such as the inference maps, which allow this behaviour to be checked and to conceptualise and justify its variation sources.

Finally, to generalise the behaviour analysis of the previous example, different websites’ evaluations have been simulated by using both methods in the final subsystem. The analysis has considered three replicas of each input variable’s score combination (considering five possible levels for each variable: from very low to very high). This supposes the analysis of up to different [5^3*5=625] groups of three values. In 47,68% of these valuations (298 out of 625), the FIS evaluation method gave significantly lower values than the WPM. In the rest, no significant differences were found. These results corroborate FIS’ better adequacy when a non-linear behaviour of the evaluation system is expected.

4.1. Advantages and Disadvantages of the proposed evaluation methods.

In view of all the reasons expressed in previous sections, Table 11 summarises the main advantages and disadvantages of each WPM and FIS evaluation methods.

5. Conclusions

The main objective of this paper is to propose an alternative model for utilitarian quality evaluation in B2C websites. When this model is supported by a fuzzy inference system, it improves some behaviour drawbacks of simpler evaluation methodologies and makes the embedded knowledge in the evaluation system more interpretable and intuitive in order to be better managed.

Regarding the theoretical implications of the paper, two methodologies have been proposed to check the model: a weighted point method and a fuzzy inference system. The first method, although is easy to put into practice, poses some inconveniences such us: an excessively linear behaviour in the evaluation, the difficulty of setting disqualifying restrictions in one or more variables of the model or the necessity of normalising the ranges of the variables. These inconveniences are solved by using the proposed fuzzy inference system, which, in addition, allows processing the uncertainty and subjectivity associated to the assessment of determined variables in the model thanks to their linguistic treatment. In addition, fuzzy system enables to build in a guided and intuitive way the decision knowledge required to evaluate websites by means of conditional fuzzy rules, either from the expert knowledge or from the opinions supplied by website users. Results show a better interpretation of the evaluation decision knowledge thanks to the fuzzy method, which also behaves better when restrictively evaluating the scores given to a B2C website.

Regarding the business implications of the paper, the results obtained in the evaluation of a B2C website may be of help for a company to identify the weak and strong points of the company's website, thus taking preventive and corrective actions to improve future evaluations. Furthermore, if the company picks up and dynamically processes its customers' perceptions regarding the variables of the model, the company will be able to control the evolution of its evaluation and even the company's positioning with respect to the competence in the different variables of the model.

For a future development of the contributions arising from this study, it shall be taken into account the inclusion of consumer-hedonic variables in the model and the compared analysis with other possible evaluation systems.

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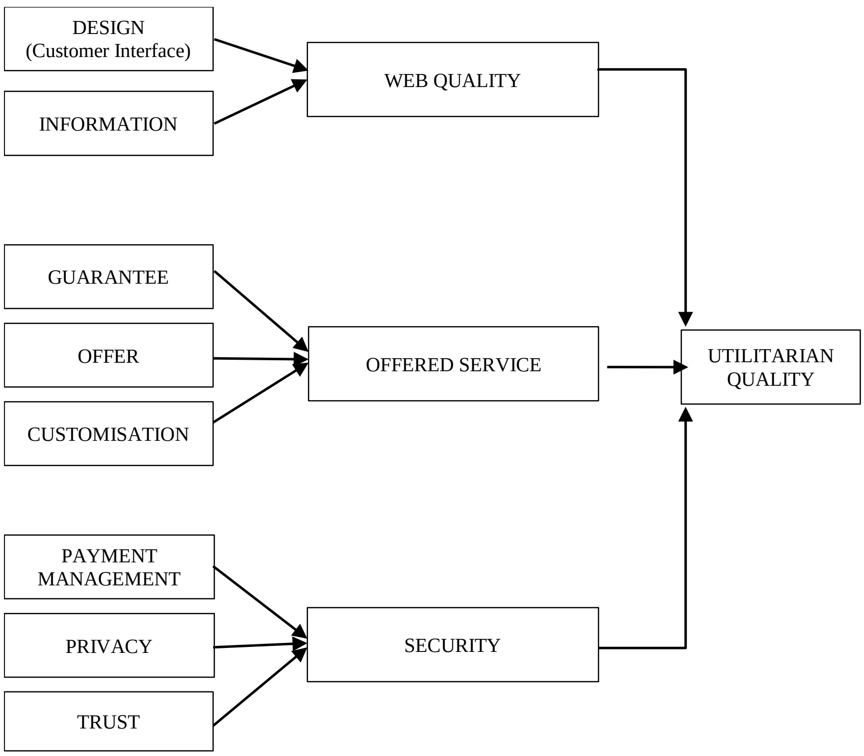

Fig. 1. Proposed model (B2C websites utilitarian eSQ evaluation).

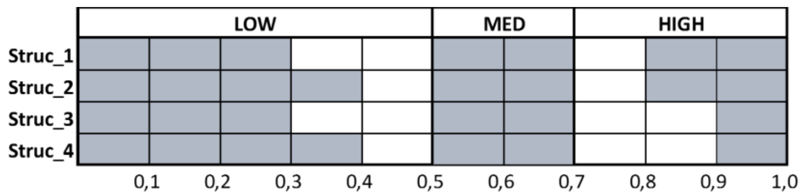

Fig. 2. Alternative core-width structures for a variable domain partition.

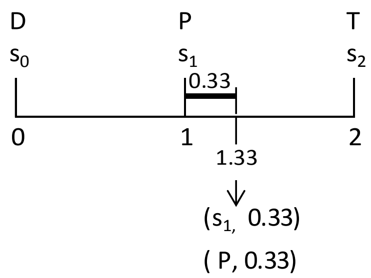

Fig. 3. Symbolic translation from EAM=1.33 to 2-tuple= (P, 0.33)

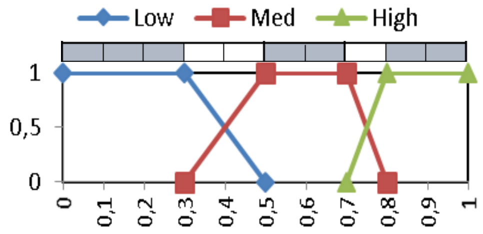

Fig. 4. Domain partitioning of the "Web Quality " subsystem input variables.

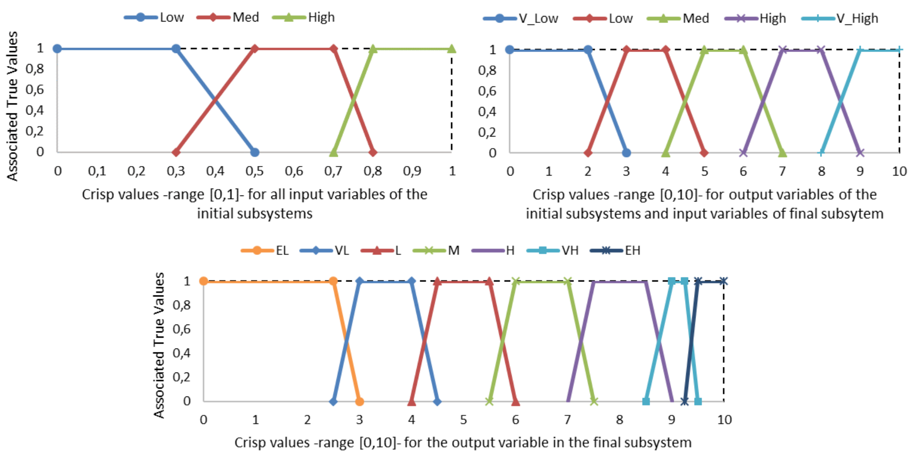

Fig. 5. Resulting labels for the input and output variables of the model.

WEB QUALITY		DESIGN		
		L	M	H
INFORMATION	L	VL	L	M
	M	L	M	H
	H	L	H	VH

OFFERED SERVICE		CUSTOMISATION								
		L	M	H	L	M	H	L	M	H
OFFER	L	VL	VL	VL	L	L	L	L	M	M
	M	L	L	L	M	M	M	M	H	H
	H	L	M	M	M	M	H	H	H	VH
		L			M			H		
		GUARANTEE								

SECURITY		TRUST								
		L	M	H	L	M	H	L	M	H
SERVICE PRIVACY	L	VL	VL	VL	L	L	M	M	M	VH
	M	VL	L	L	L	M	M	M	H	VH
	H	VL	M	M	M	M	H	H	H	VH
		L			M			H		
		PAYMENT MANAGEMENT								

FINAL EVALUATION		WEB QUALITY																								
		VL	L	M	H	VH	VL	L	M	H	VH	VL	L	M	H	VH	VL	L	M	H	VH	VL	L	M	H	VH
OFFERED SERVICE	VL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	VL	VL	L	M	M	M	M	M	H	H	H	H	H	VH	VH
	L	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	VL	L	L	M	M	M	M	M	H	H	H	H	VH	VH	VH
	M	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	L	L	M	M	M	M	M	H	H	H	H	VH	VH	VH	VH
	H	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	L	M	M	M	M	H	H	H	H	H	VH	VH	VH	VH	EH
	VH	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	M	M	M	M	M	H	H	H	H	H	VH	VH	VH	EH	EH
		VL					L					M					H					VH				
		SECURITY																								

Labels: EL – Extremely low; VL – Very low; L – Low; M – Medium; H – High; VH – Very High; EH – Extremely High

Fig. 6. Rule-Bases to evaluate the utilitarian quality of B2C websites using a FIS.

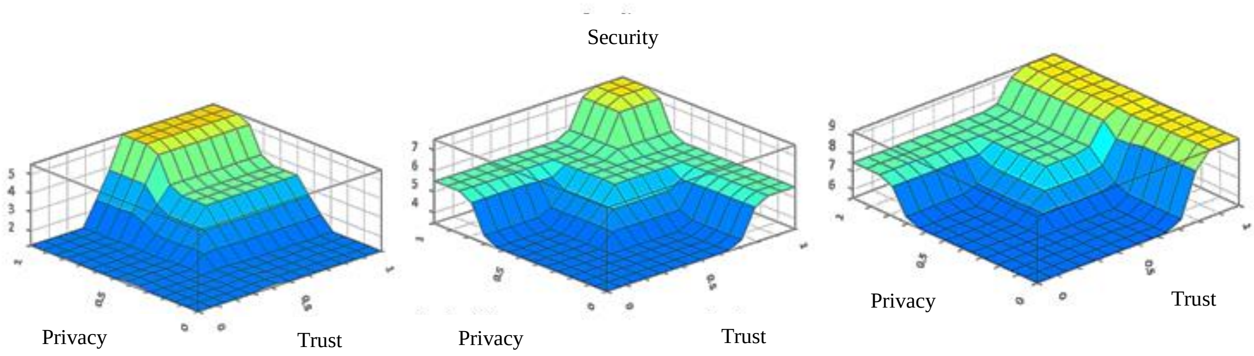

Fig. 7. Maps of solutions of the Security subsystem.
(Left: low payment management; Central: medium payment management; Right: high payment management)

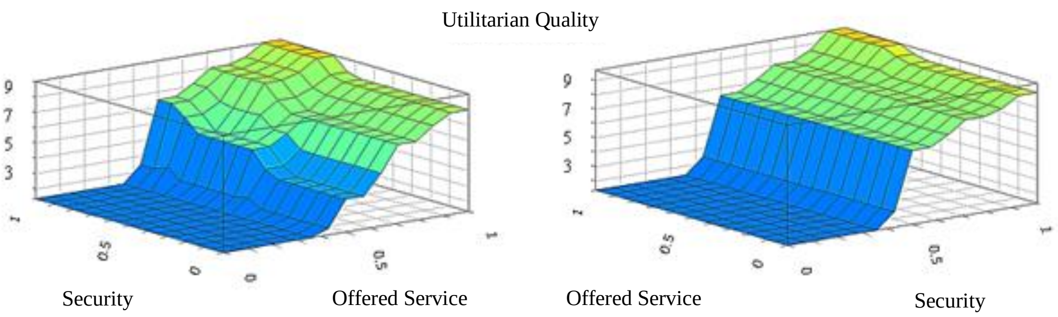

Fig. 8. Maps of solutions for the Utilitarian Quality evaluation.

(Left: low Web Quality; Right: high Web Quality)

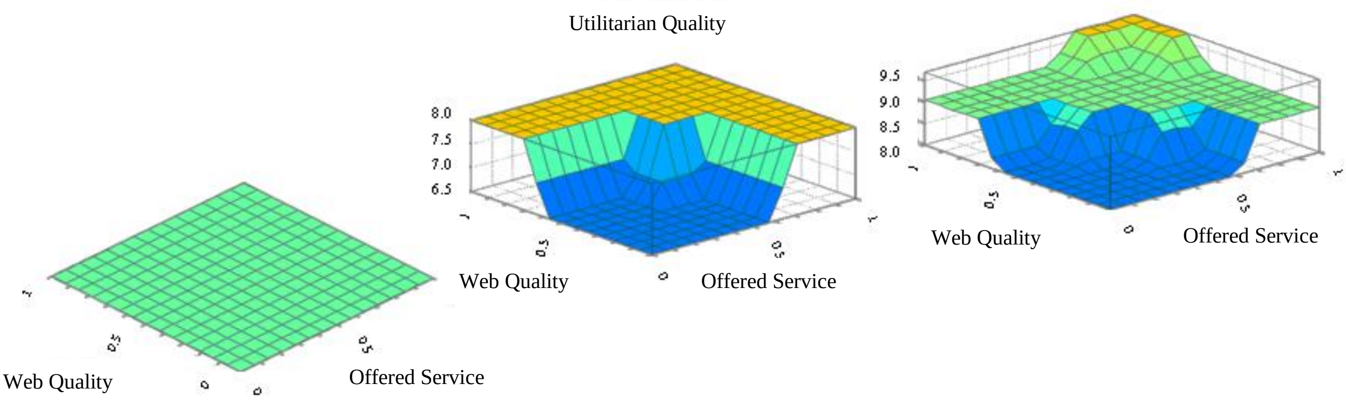

Fig. 9. Maps of solutions for the Utilitarian Quality evaluation
(Left: low Security; Central: medium Security; Right: high Security)

Table 1
Relevant dimensions in the utilitarian quality evaluation of B2C websites.

FACTOR	DEFINITION	AUTHORS
DESIGN (Customer Interface)	Design is an activity that consists in web sites planning, modelling and implementing. Web sites design plays an important role in acquiring and maintaining customers as well as in generating loyalty since web site aesthetics is considered to be a key point in e-service quality.	[03, 06, 11, 13, 22, 23, 24, 25, 26, 27, 26]
INFORMATION	Information, in general terms, is defined as an organised set of processed data that make up a message that changes the knowledge status of the subject or system that receives the message. Different authors emphasise in the importance of the quality of the information to obtain a favourable evaluation in a determined web site.	[22, 23, 24, 27, 28]
GUARANTEE	Guarantee, refers to the action that a person or company executes so as to consolidate what had been accorded. The presentation of a guarantee intends to give a bigger security to the fulfilling of an obligation or to the payment of a debt.	[28, 29, 30]
OFFER	An offer is the proposal posed to execute or accomplish something. In the specific case of e-commerce, this factor is mentioned to refer to the quality and variety of products and services offered by a determined website to produce confidence and empathy in any given customer.	[03, 15]
CUSTOMISATION	Customisation is defined as the capability of adapting products or services to the necessities of the customer, so that the customer feels exclusive, special, unique and different.	[24, 25, 31]
PAYMENT MANAGEMENT	Payment management is understood as the guarantee of protection regarding transactions and means of payment used during the purchasing process.	[14, 20, 22, 24, 25, 27, 28, 30]
PRIVACY	Privacy is defined as the guarantee of protection of the sensitive data supplied by the customer regarding the storage, processing and preservation of the data. In e-commerce, these are the customer's personal data.	[03, 06, 12, 20, 22, 24, 26, 27]
TRUST	Trust is defined as the expectations set on something or someone. In e-commerce, trust refers to the hope of satisfying the on-line buyers expectations.	[24, 26]

Table 2 Range partitions and cut off points of the model factors.

	FACTORS	RANGE PARTITIONS CUT OFF POINTS
INPUT VARIABLES	DESIGN [DESI] INFORMATION [INFO] OFFER [OFFE] CUSTOMISATION [CUSTO] PRIVACY [PRIVA] TRUST [TRUST]	Range: 0-1 point [0- 0,5]: Low [0.5-0.7]: Medium [0.7-1.0]: High
	GUARANTEE [GUAR]	Range: 0-5 years [0-2]: Low [2-3]: Medium [3-5]: High.
	PAYMENT MANAGEMENT [PAYMA	Range: 0-1 Point [0-0.7]: Disqualified [0.7-0.9]: Medium [0.9-1.0]: High.
OUTPUT VARIABLES	WEB QUALITY DIMENSION OFFERED SERVICE DIMENSION SECURITY DIMENSION	Range: 0-10 Points [0-2.5]: Very Low [2.5-4.5]: Low [4.5-6.5]: Medium [6.5-8.5]: High. [8.5-10]: Very High.

Table 3

Factors weights of each model subsystem, estimated by AHP.

	WEB QUALITY		OFFERED SERVICE			SECURITY			B2C WEB EVALUATION		
WEIGHTS	W_{DESI}	W_{INFO}	W_{GUAR}	W_{OFFE}	W_{CUSTO}	W_{PAYMA}	W_{PRIVA}	W_{TRUST}	W_{WQ}	W_{OS}	W_{S}
	0,6	0,4	0,33	0,33	0,33	0,5	0,3	0,2	0,15	0,15	0,7

Table 4

Technical report of the survey.

UNIVERSE	Regular users of purchase/search of TF products through the Internet.
GEOGRAPHICAL AREA	Spain
SAMPLE PROCEDURE	Discretionary
SAMPLE SIZE	405
SCALE	Likert: ‘0-strongly disagree’ to -10-strongly agree’
SAMPLE ERROR	± 2,42 %, confidence level 95 %; p=q=0,5
INFORMATION GATHERED	Likert-scale evaluation of the attributes that integrate the factors that explain utilitarian quality.
CUSTOMER SEGMENTATION	Only search information. Search and purchase.
FIELDWORK PERIOD	November 2013- February 2014

Table 5 Factorial analysis and alpha Cronbach coefficients.

Subdimensions	**Factors**	**Items**	**Loading factors**	**% Variance Explained**	**% Accumulated Variance**	**Alpha Cronbach coefficient**
Web Quality	Design	DESI3	0,781	64,162	65,626	0,899
		DESI4	0,761			
		DESI5	0,813			
		DESI6	0,648			
	Information	INFO1	0,718	59,637		
		INFO3	0,690			
		INFO4	0,735			

		INFO5	0,804			
		INFO6	0,746			
Offer Service	Guarantee	GUAR1	0,692	60,672	54,938	0,877
		GUAR2	0,762			
		GUAR3	0,716			
		GUAR4	0,724			
		GUAR5	0,694			
	Offer	OFFE1	0,748	53,231		
		OFFE2	0,569			
		OFFE3	0,739			
		OFFE4	0,563			
		OFFE5	0,609			
	Customisation	CUSTO2	0,519	72,941		
Security	Payment Management	PAYMA1	0,709	73,341	60,510	0,833
		PAYMA2	0,815			
		PAYMA4	0,747			
	Privacy	PRIVA1	0,757	74,359		
		PRIVA2	0,674			
	Trust	TRUST1	0,520	77,747		
		TRUST2	0,717			

Table 6 Measurement scales validation for Web Quality, Offer Service and Security sub-dimensions.

Factors	**Items**	**Standardized Parameters Lambda**	**t-Student**	**Composite reliability index**	**AVE**
Design	DESI3	0,762	9,728	0,818	0,54
	DESI4	0,740	10,217		
	DESI5	0,806	10,403		
	DESI6	0,594	10,193		
Information	INFO1	0,671	12,077	0,832	0,50
	INFO3	0,639	13,715		
	INFO4	0,706	10,308		
	INFO5	0,788	11,277		
	INFO6	0,718	10,976		
		Correlation	**95 % Confidence Interval**		
Design-Information		0,96	0,94-0,976		
Adjustment Results of the Model:		χ^2(g.l.)=464,160 (36) P<0,001	BBNNFI= 0,916 CFI= 0,939		

Factors	**Items**	**Standardized Parameters Lambda**	**t-Student**	**Composite reliability index**	**AVE**
Guarantee	GUAR1	0,661	14,123	0,839	0,51
	GUAR2	0,732	16,177		
	GUAR3	0,753	16,837		
	GUAR4	0,722	15,878		
	GUAR5	0,699	15,208		
Offer	OFFE1	0,777	17,179	0,782	0,50
	OFFE2	0,563	11,388		
	OFFE3	0,737	15,999		
	OFFE4	0,584	11,906		
	OFFE5	0,554	11,157		
		Correlation	**95 % Confidence Interval**		
Guarantee - Offer		0,81	0,780-0,840		
Guarantee – Customisation		0,87	0,755-0,981		
Offer – Customisation		0,85	0,763-0,876		
Adjustment Results of the Model:		χ^2(g.l.)=713,648 (55) P<0,001	BBNNFI= 0,88 CFI= 0,914		

Factors	**Items**	**Standardized Parameters Lambda**	**t-Student**	**Composite reliability index**	**AVE**
Payment Management	PAYMA1	0,745	10,889	0,819	0,61
	PAYMA2	0,843	7,771		
	PAYMA3	0,734	11,119		
Privacy	PRIVA1	0,760	8,195	0,660	0,52
	PRIVA2	0,641	11,500		
Trust	TRUST1	0,588	11,358	0,755	0,62
	TRUST2	0,944	10,221		
		Correlation	**95 % Confidence Interval**		
Payment Management - Privacy		0,81	0,765-0,847		

Payment Management -Trust	0,68	0,478-0,578
Privacy-Trust	0,53	0,627-0,735
Adjustment Results of the Model:	χ^2(g.l.)=24,46 (11) P<0,001	BBNNFI= 0,975 CFI= 0,99

Table 7
Set of preference linguistic terms.

	Label	Concept	TFNs	2-tuples
s0	D	Disagreement	(0.0 0.0 0.3 0.5)	(D, 0)
s1	P	Parcial Agreement	(0.3 0.5 0.5 0.7)	(P, 0)
s2	T	Total Agreement	(0.5 0.7 1.0 1.0)	(T, 0)

Table 8
Rating on linguistic preferences by experts in 4 alternative structures to define the cores of a partition.

	Struc_1	**Struc_2**	**Struc_3**	**Struc_4**
Exp1	T	P		
Exp2	P			T
Exp3	T	P		
Exp4	P	T		
Exp5		P		T
Exp6	T		P	
EAM	**1.33**	**0.83**	**0.17**	**0.67**
2-tuples	**(P, 0.33)**	**(P, -0.17)**	**(D, 0.17)**	**(P, -0.33)**

Table 9
Linguistic assessments given by experts to the output variables of the Web Quality inference subsystem. Collective preference vectors, distances and final assigned labels.

Design	**Inform**	**Exp1**	**Exp2**	**Exp3**	**Exp4**	**Exp5**	**Exp 6**	**Collective preference vectors (CPV)**				**DISTANCES from each CPV to**					**Final Assigned Label**
												VL	**L**	**M**	**H**	**VH**	
L	L	VL	L	VL	L	VL	VL	0,67	1,00	2,67	3,67	0,82	1,45	3,26	5,10	6,95	VL
	M	L	M	L	L	M	L	2,67	3,67	4,67	5,67	2,94	0,69	1,15	2,99	4,85	L
	H	M	M	L	L	L	L	2,67	3,67	4,67	5,67	2,94	0,69	1,15	2,99	4,85	L
M	L	L	M	L	M	L	L	2,67	3,67	4,67	5,67	2,94	0,69	1,15	2,99	4,85	L
	M	L	M	M	M	L	M	3,33	4,33	5,33	6,33	3,55	1,31	0,53	2,38	4,24	M
	H	M	H	H	H	M	H	5,33	6,33	7,33	8,33	5,39	3,15	1,31	0,53	2,41	H
H	L	L	M	H	M	M	H	4,33	5,33	6,33	7,33	4,47	2,23	0,38	1,45	3,32	M
	M	M	H	VH	H	M	H	5,67	6,67	7,67	8,50	5,70	3,46	1,61	0,14	2,10	H
	H	H	VH	VH	VH	H	VH	7,33	8,33	9,33	9,67	7,22	4,99	3,14	1,27	0,57	VH

Table 10 Comparative results between WPM and FIS.

	WEB QUALITY				**OFFERED SERVICE**					**SECURITY**					**UTILITARIAN QUALITY**		**COMPARISON**
	DESI	INFO	**WPM**	**FIS**	GUAR	OFFE	CUSTO	**WPM**	**FIS**	PAYMA	PRIVA	TRUST	**WPM**	**FIS**	**WPM**	**FIS**	Rate Var. (%)

EBAY	0,73	0,75	**7,42**	**7,33**	0,51	0,75	0,76	**6,66**	**5,93**	0,74	0,68	0,76	**7,26**	**7,03**	**7,08**	**7,50**	5,93
ZARA	0,82	0,82	**8,21**	**8,50**	0,81	0,74	0,54	**7,07**	**6,85**	0,78	0,75	0,62	**7,15**	**7,02**	**7,14**	**8,11**	13,59
PRIVALIA	0,82	0,81	**8,14**	**8,27**	0,78	0,78	0,45	**6,83**	**6,83**	0,76	0,77	0,65	**7,27**	**6,90**	**7,33**	**8,21**	12,01
BUY VIP	0,80	0,80	**7,99**	**8,04**	0,76	0,76	0,48	**6,87**	**6,80**	0,76	0,80	0,63	**7,28**	**6,64**	**7,31**	**8,23**	12,59
VENTE PRIVEE	0,81	0,84	**8,28**	**8,38**	0,78	0,79	0,31	**6,46**	**6,50**	0,86	0,80	0,61	**7,53**	**6,77**	**7,33**	**8,37**	14,19
ASOS	0,83	0,83	**8,31**	**8,44**	0,78	0,81	0,57	**7,29**	**6,89**	0,70	0,65	0,47	**6,04**	**6,94**	**7,06**	**8,16**	15,58
WEB Z	0,95	1,00	**9,76**	**9,25**	0,66	0,80	0,9	**7,9**	**8,32**	0,3	0,7	0,6	**5,34**	**3,50**	**6,0**	**1,35**	-77,50

Table 11 Advantages and disadvantages of WPM and FIS methods.

	ADVANTAGES	DISADVANTAGES
WPM	• Ease of use and implementation.	• Excessive linearity in valuations. • It does not sufficiently penalise critical variables of the model that are poorly valued. • Need to normalise the values of certain variables of the model • Does not allow to aggregate valuation knowledge in a guided and intuitive way
FIS	• It is able to emulate human reasoning processes in decision making from ill-defined or vague data. • It Prevents model variables from being normalised. • It allows to treat nonlinear behaviours in the evaluation method. • Better interpretation of the knowledge embedded it the evaluation model	• More complex calculations (although there is free software that greatly facilitates calculations)

ANNEX A: Utilitarian quality factors and attributes

Table A1
Utilitarian quality factors and attributes.

FACTORS	ATTRIBUTES DESCRIPTION (observable variables)	CODE	BIBLIOGRAPHY
Design	*Web Site accessible at any time.*	*DESI1*	Compiled from Expert Panel and [03, 06, 11, 13, 22, 23, 24, 25, 26, 27, 26]
	Attractive site design (colours, font size, photographes).	*DESI2*	
	Appropriate site content download.	DESI3	
	Web site content arrangement (per sex, type of product, price).	DESI4	
	Web site easy use.	DESI5	
	Absence of undesired links and ads.	DESI6	

	Catalogues download possibility.	*DESI7*	
Information	Relevant information.	INFO1	Compiled from Expert Panel and [22, 23, 24, 27, 28]
	Web site in purchaser's language.	*INFO2*	
	Up-to-date information.	INFO3	
	Offered information without errors (neither in content nor in translation).	INFO4	
	Appropriate response time (to a particular request).	INFO5	
	Available information about customer's rights.	INFO6	
Guarantee	Easy customer company contact (telephone, fax, e-mail, chat).	GUAR1	Compiled from Expert Panel and [28, 29, 30]
	Guarantee that the offered item is equal to the sent one.	GUAR2	
	Return possibility due to change in size or product.	GUAR3	
	Availability of order id to visualize its status.	GUAR4	
	Existence of a statement of intention of reclaiming non-received items.	GUAR5	
Offer	Offered products quality-price ratio.	OFFE1	Compiled from Expert Panel and [03, 15]
	Better offers in the online shop that in the traditional one.	OFFE2	
	Wide variety of fashion-related products availability.	OFFE3	
	Competitive prices.	OFFE4	
	Offer services attractive.	OFFE5	
Customisation	Possibility of creating exclusive products.	CUSTO1	Compiled from Expert Panel and [24, 25, 31]
	Suggestions and combinations with the selected product.	CUSTO2	
	Possibility of tailoring the web information by using filters (sex, sex, brand, and price).	*CUSTO3*	
Payment Management	Availability of safe ways to transmit information.	PAYMA1	Compiled from Expert Panel and [14, 20, 22, 24, 25, 27, 28, 30]
	Payment system participant identification (company-mediator-customer).	PAYMA2	
	Availability of different payment alternatives (e.g. cash on delivery).	*PAYMA3*	
	Possibility of creating an account with password (register).	PAYMA4	
Privacy	The web site ensures that the information supplied by the customer will not be shared with other companies or web sites.	PRIVA1	Compiled from Expert Panel and [03, 06, 12, 20, 22, 24, 26, 27]
	Privacy in product delivery.	PRIVA2	
Trust	Availability of other customers' comments (actual and many).	TRUST1	Compiled from Expert Panel and [24, 26]
	Availability of online confidence certificate.	TRUST2	
	Possibility of order cancelation.	*TRUST3*	

NOTE: The finally removed attributes are in italics.